Environmental Assessment of Statoil's Geophysical Program for the Jeanne d'Arc and Central Ridge/ Flemish Pass Basins, 2011-2019

Prepared by

LGL LIMITED
environmental research associates

for

Statoil

March 2011
Project No. SA1121

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Prepared by

LGL Limited
environmental research associates
388 Kenmount Road, Box 13248, Stn. A.
St. John's, NL A1B 4A5
Tel: 709-754-1992
rbuchanan@lgl.com
www.lgl.com

In Association With

Canning & Pitt Associates, Inc.
Box 21461, St. John's, NL A1A 5G2
Tel: 709-738-0133
www.canpitt.ca

and

Oceans Limited
65A LeMarchant Road
St. John's, NL A1C 2G9
Tel: 709-753-5788

Prepared for

Statoil Canada Ltd.
Level II, Cormack Building
2 Steer's Cove
St. John's, NL A1C 6J5

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1.0 Introduction

Statoil ASA through its subsidiary Statoil Canada Ltd. (herein referred to as Statoil) proposes to undertake geophysical survey programs including seismic, electromagnetic, and localized geohazard surveys in the Jeanne d'Arc and Flemish Pass basins (see Figure 1.1) from 2011 through 2019. Statoil anticipates carrying out a 3D and a small number of 2D profiles during 2011 and subsequent surveys, including geohazard and electromagnetic surveys, over the remaining eight years. The proposed Project Area includes lands held by Statoil and partners that were previously approved for seismic and geohazard surveys under the *Canadian Environmental Assessment Act* (*CEAA*) (see LGL 2008a). The present environmental assessment (EA) includes the original 2008 seismic area in Jeanne d'Arc Basin (42,260 km^2), plus an additional area in Flemish Pass Basin (22,110 km^2) to the northeast that encompasses several new exploration licenses (ELs) of interest (Figure 1.1). The temporal scope of the original EA (2008-2016) has been expanded to 2011 to 2019. This document is a screening level EA as defined by the *CEAA* for multiyear seismic and geohazard survey programs. Electromagnetic surveys are not specifically assessed in this document because survey information is unavailable at this time. However, Statoil commits to submitting an amendment to this EA when adequate electromagnetic survey project description information becomes available.

1.1. Relevant Legislation and Regulatory Approvals

An *Authorization to Conduct a Geophysical Program* will be required from the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB). The C-NLOPB is mandated by the *Canada-Newfoundland Atlantic Accord Implementation Act* and the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*. Offshore geophysical surveys (including geohazard surveys) on federal lands are subject to screening under the *CEAA.* In addition, the *CEAA* specifies that a marine seismic survey with an output level of 275.79 kPa at a distance of one metre from the seismic energy source (i.e., ~228.69 dB//1µPa@1m) requires an EA. The seismic survey activities described as part of the Project typically exceed the defined threshold level (if considering instantaneous levels). The C-NLOPB is the lead Responsible Authority (RA) for the EA and acts as the federal environmental assessment coordinator or FEAC. Because seismic survey activities have the potential to affect seabirds, marine mammals, sea turtles, and fish and fisheries, the Fisheries and Oceans Canada (DFO) and Environment Canada (EC) are the primarily interested agencies. Legislation that is relevant to the environmental aspects of the Project includes:

- *Canada-Newfoundland Atlantic Accord Implementation Act*
- *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*
- *Canadian Environmental Assessment Act*
- *Oceans Act*
- *Fisheries Act*
- *Navigable Waters Act*
- *Canada Shipping Act*
- *Migratory Bird Act*
- *Species at Risk Act*

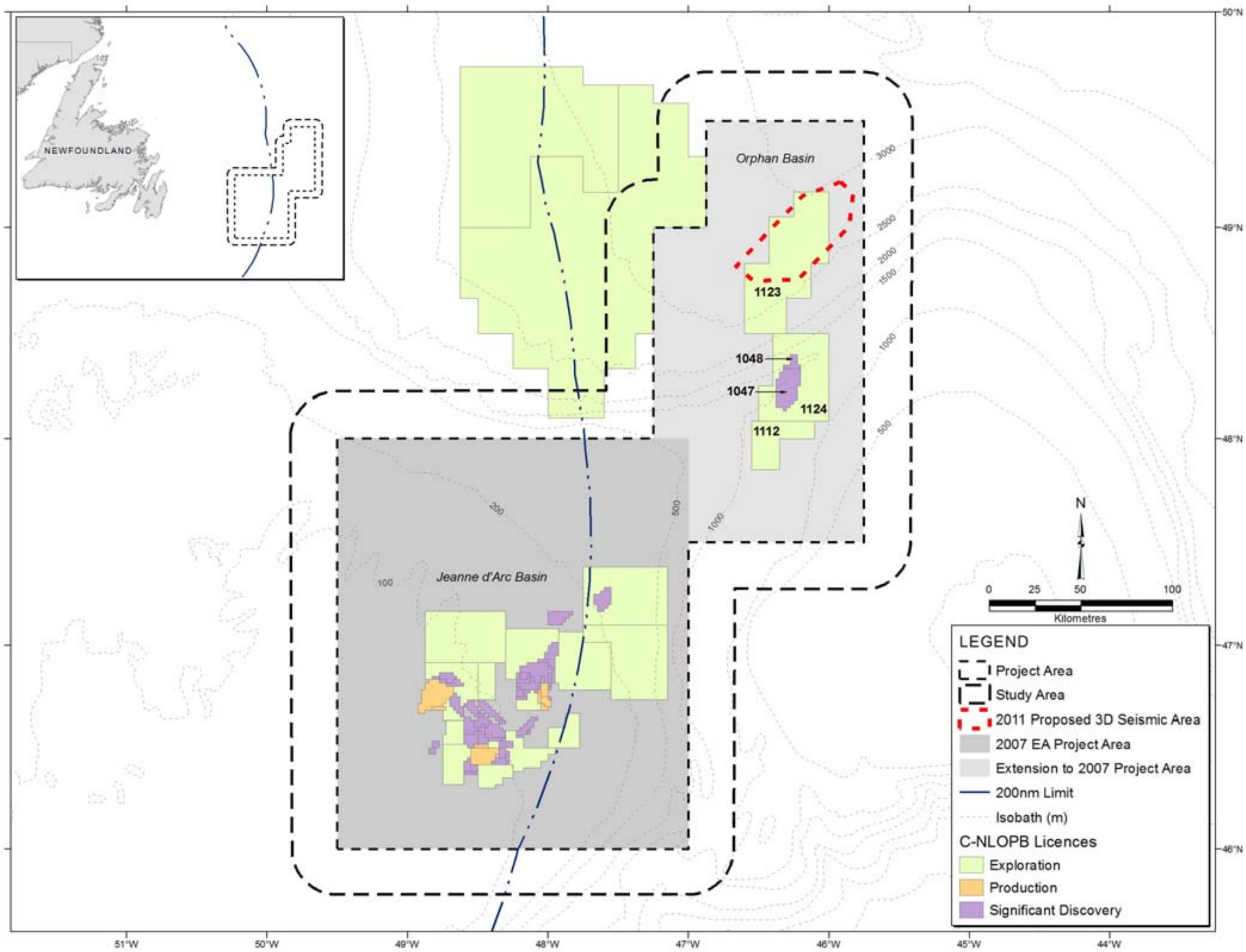


Figure 1.1. Locations of proposed 3-D seismic program for Statoil in 2011, the Project Area and corresponding Study Area for other potential seismic and geohazard surveys.

One of the specific guidelines issued by the C-NLOPB, the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (February 2011), is directly relevant to this undertaking. It outlines mitigation and monitoring requirements for marine mammals and sea turtles for the program. As indicated in the *Guidelines*, the Project will follow DFO's *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment* that forms Appendix 2 of the Guidelines.

1.1.1. Environmental Assessment Update Process

The issuance of a geophysical/geotechnical work authorization under the *Atlantic Accord Implementation Act*s requires a screening level EA pursuant to the *CEAA*.

The geophysical survey activities described in this EA may be undertaken at various times over the coming nine years. This EA has been developed taking into account the expected period of time during which these project activities will occur.

Authorizations issued under the *Atlantic Accord Implementation Acts* for the kinds of activities described in this assessment may be valid for one to five years at the discretion of the C-NLOPB. Therefore, notwithstanding the fact that this EA has been written to cover a period of nine years based on the best available knowledge at this time, Statoil recognizes that should any authorizations need to be renewed during that time period that there will be a regulatory requirement to ensure that the EA is still current and valid to support the renewal of any applicable authorizations. To that end, Statoil will during the first quarter of each year that work is planned during 2012–2019, submit documentation to the C-NLOPB to attest that:

- the scope and nature of activities planned and addressed under this EA have not changed;
- the nature of the species at risk in the Project and Study Areas have been updated and results have not led to predictions of significant effects;
- the nature and extent of the fishing activities being undertaken in the Project Area have been updated and have not changed such that project activities pose any potential effects not previously assessed; and,
- the mitigation measures defined and committed to in the EA are still valid and will continue to be implemented.

Should Statoil determine that changes to the project activities or the environmental aspects noted above have taken place it will consult with the C-NLOPB to determine the need for submission of an update to the EA. As noted earlier, if electromagnetic surveys are planned in 2012-2019, Statoil will submit a specific environmental assessment amendment to the C-NLOPB as part of its annual operational planning process.

As part of the ongoing consultation processes, Statoil will consult with stakeholders each year in the context of preparing the above-noted submission(s) to the C-NLOPB. These meetings will outline Statoil's planned activities for the upcoming year and discuss issues of mutual interest and concern.

1.2. The Proponent

Statoil is a Norwegian company with worldwide interests and with established offices in Canada in 1996 in Calgary, Alberta and St. John's, Newfoundland and Labrador (NL). Statoil is a globally active company involved in exploration and development of crude oil and natural gas and is committed to maximizing returns to stakeholders in an ethical, socially responsible and environmentally responsible way.

Statoil has interests in various exploration licenses (EL), significant discovery licences (SDL), and production licences (PL) in the NL Offshore Area. In the Grand Banks area, Statoil is a partner in the Hibernia, Hibernia South Extension, and Terra Nova producing oilfields, is a partner in the proposed Hebron project, and is operator of three SDL's and five EL's. Additionally, Statoil may acquire new licenses resulting from a Call for Bids or the acquisition of lands from other operators.

1.2.1. Hydro and Statoil Merger

Since the 2008 EA was approved, the Oil and Gas portion of Norsk Hydro merged with Statoil. Following the merger, all Hydro's Newfoundland and Labrador assets became part of the merged company. The merged company operated under the name StatoilHydro during 2008–2009, and was renamed Statoil in 2010.

1.2.2. Proponent's Objectives

Statoil's long-term goals are to

- Increase its equity interests in offshore NL;
- Plan for and execute Statoil-operated exploration, appraisal/delineation, development, and production activities in a timely manner; and
- Increase its portion of total global production originating from Canada.

Statoil's goals for the geophysical survey activities described in this EA include:

- Execute a cost-effective program from St. John's, while maintaining our policy of strict health, safety and environmental responsibilities that creates zero harm to the people and environment, and meets all due diligence requirements;
- Establish and maintain cost-effective relationships with suppliers and contractors, creating long-term mutual benefits and local infrastructure; and
- Optimize synergy opportunities with other operators in the area.

Statoil Canada Ltd. Offshore Upstream operations are managed from its St. John's, NL office and operations will be supported by local logistics infrastructure and resources to the extent possible.

Statoil is committed to conducting its operations in a manner that respects the environmental characteristics of the immediate area. Statoil will comply with all applicable laws, regulations, guidelines, and codes of practice as well as particular commitments made during the application and review process for which this EA is submitted.

1.2.3. Proponent's Management System

Statoil Canada Ltd. Offshore Upstream operations conform to Statoil's corporate management system. Statoil's management system is the set of principles, policies, processes and requirements which support our organization in fulfilling the tasks required to achieve our objectives.

Our management system has three main objectives:

1. Contribute to safe, reliable and efficient operations and enable us to comply with external and internal requirements;
2. Help us to incorporate our values, our people and our leadership principles in everything we do; and
3. Support our business performance through high-quality decision making, fast and precise execution, and continuous learning.

The management system is detailed in governing documentation, which includes the Statoil Book, common function requirements as well as requirements specific to the business areas. Statoil's management plan encompasses specific components, including but not limited to pollution prevention policies and procedures, emergency response plans, spill response plans, compensation plans, and fisheries liaison/interactions policies and procedures. Relevant plans and policies are discussed in the EA. All of our people are required to comply with our management system including relevant governing documentation, in addition to adhering to country-specific laws and regulatory requirements.

Compliance means to follow external and internal requirements and to achieve the required performance the management system shall be used systematically in day-to-day work. Training in the use of the work processes is part of this systematic approach. When performing a specific activity it is necessary to consider risks. An assessment may lead to a need for improvement or a need for dispensation from governing documentation. Leadership is also required in order to achieve compliance. This includes communicating the management system, acting as a role model and coaching the organization in the use of the management system.

The management system is continuously evaluated to ensure it is up-to-date, improved and capable of handling existing and new risks. Monitoring is conducted to reduce downside risk, ensure the quality and effectiveness of the management system, and the quality of processes and products.

Statoil's approach to Health, Safety and Environment matters, which is of particular relevance to this EA, is founded in the following statement of principles from "The Statoil Book" (Figure 1.2).

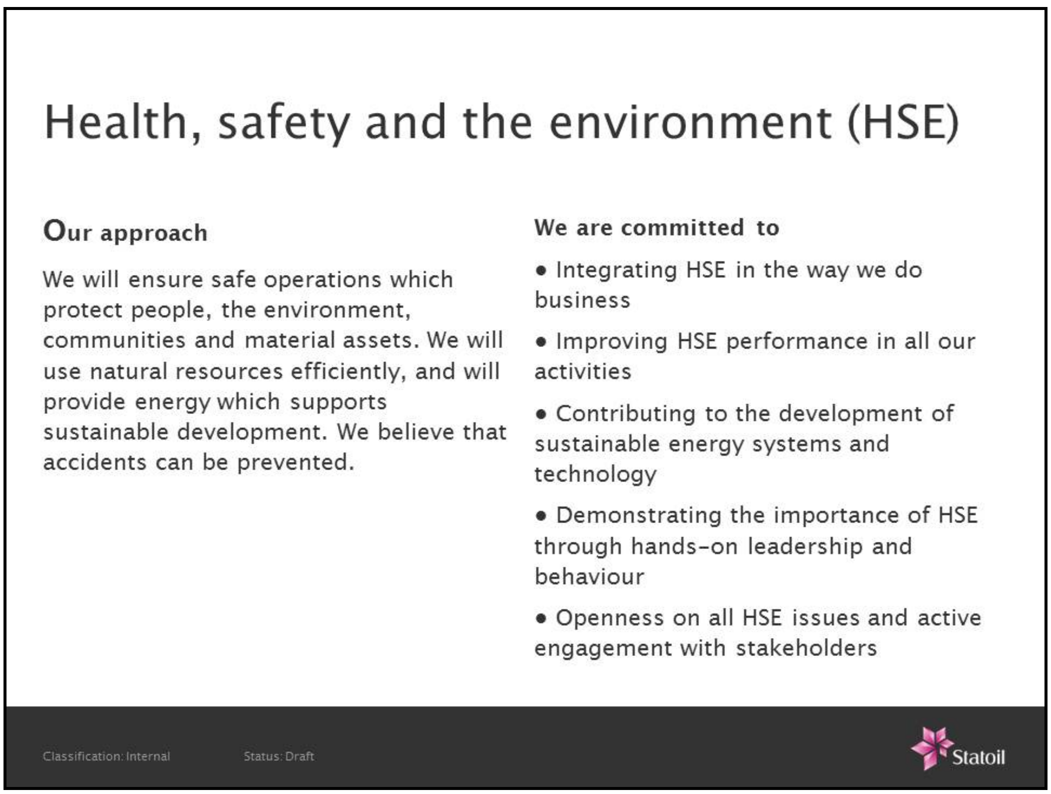


Figure 1.2. HSE approach and commitments from the Statoil Book.

1.3. Social Responsibility and Canada-Newfoundland and Labrador Benefits

Statoil is committed to improving the communities in which it operates, including supporting charitable, cultural, and community organizations. It is also committed to supporting research and development, education and training, and technology transfer. Statoil is committed to employing qualified individuals without regard to race, religion, gender, national origin, or disability.

Statoil is committed to the industrial and employment benefits objectives of the *Canada-Newfoundland Atlantic Accord Implementation Act* (the *Act*) and C-NLOPB guidelines dated February 2006 including full and fair opportunity and first consideration. In the spirit of the *Act,* Statoil actively seeks to enhance the participation of individuals and organizations from NL and elsewhere in Canada in offshore oil and gas activity on the East Coast.

Statoil also encourages its suppliers and service providers to implement these principles.

1.4. Contacts

Relevant contacts at Statoil for the seismic program include:

Ms. Hege Rogno
Vice President, Offshore Upstream
Statoil Canada Ltd.
Level II, Cormack Building
2 Steer's Cove
St. John's, NL A1C 6J5
Phone: (709) 738-8472
Fax: (709) 726-9053
hros@statoil.com

Mr. Michael McDonough
Leading Geophysicist
Statoil Canada Ltd.
Suite 2100
635-8th Avenue SW
Calgary, AB T2P 3M3
Phone: (403) 718-8759
Fax: (403) 234-0103
mmcd@statoil.com

Mr. Derek Sullivan
HSE Manager
Statoil Canada Ltd.
Level II, Cormack Building
2 Steer's Cove
St. John's, NL A1C 6J5
Phone: (709) 738-8477
Fax: (709) 726-9053
ders@statoil.com

2.0 Proposed Project

2.1. Name and Location

The official name of the Project is the *"Statoil Canada Ltd. Geophysical Program for the Jeanne d'Arc Basin and Central Ridge/Flemish Pass Basin, 2011-2019*."

Generally located on the northeastern Grand Banks and off the Banks to the northeast (Figure 1.1), seismic surveys could be conducted on any current or future land holdings Statoil may acquire in this area from 2011 through 2019. The current licenses held by Statoil exclusively, or in partnership with others, are provided in Figure 1.1 and Table 2.1. Statoil has interests in 30 significant discovery licences (SDL), 9 exploration licenses (EL), and 5 production licenses (PL) in the Jeanne d'Arc Basin and vicinity, and operates 8 of these developments (see highlighted licenses in Table 2.1).

Statoil may participate in arrangements with other operators to conduct seismic exploration on their behalf, or vice versa, within the geographic and temporal scope of this Project Description.

Table 2.1. Current Statoil interests in Jeanne d'Arc and Flemish Pass basins.

License	Name	Operator	Gross Hectares	Statoil %
PL 1001	Hibernia	HMDC	22 285	5.00
PL 1002	Terra Nova	Suncor	12 800	15.00
PL 1003	Terra Nova	Suncor	355	15.00
PL 1004	Terra Nova	Suncor	1 065	15.00
PL 1005	Hibernia South Extension	HMDC	1 416	25.00
SDL 197		ExxonMobil	7 722	3.75
SDL 200A/B		ExxonMobil	8 765	7.50
SDL 208A		Suncor	1 424	15.00
SDL 1001		ExxonMobil	3 883	7.50
SDL 1002		ExxonMobil	5 664	7.50
SDL 1003		ExxonMobil	3 894	7.50
SDL 1004		Suncor	708	11.27
SDL 1005		ExxonMobil	354	7.50
SDL 1006	Hebron	ExxonMobil	5 325	7.50
SDL 1007	Hebron	Suncor	3 195	11.27
SDL 1009	Hebron	Suncor	6 390	11.27
SDL 1010	Hebron	Suncor	3 550	11.27
SDL 1011		Husky	5 321	7.50
SDL 1012		Husky	355	4.50
SDL 1013		Imperial	2 136	4.73
SDL 1014		Imperial	2 487	4.73
SDL 1017		Imperial	356	5.40

License	Name	Operator	Gross Hectares	Statoil %
SDL 1031		Husky	7 045	7.50
SDL 1035		Suncor	1 420	15.75
SDL 1036		Suncor	1 420	15.00
SDL 1037		Suncor	1 065	27.40
SDL 1038		Suncor	356	27.40
SDL 1039		Suncor	2 492	27.80
SDL 1040	***West Bonne Bay***	***Statoil***	***3 195***	***65.00***
SDL 1041		Chevron	3 883	9.99
SDL 1042		Husky	3 897	15.00
SDL 1046		Husky	5 320	15.00
SDL 1047	***Mizzen***	***Statoil***	***22 007***	***65.00***
SDL 1048	***Mizzen North***	***Statoil***	***3 773***	***65.00***
EL 1092	North Mara	Suncor	35 674	50.00
EL 1093	Hibernia south extension	ExxonMobil	7 080	5.00
EL 1100	***River of Ponds***	***Statoil***	***30 572***	***50.00***
EL 1101	***L'Anse Aux Meadows***	***Statoil***	***21 009***	***50.00***
EL 1112	***Bay du Nord***	***Statoil***	***55 954***	***65.00***
EL 1113	Ballicatters	Suncor	19,430	50.00
EL 1122	Searcher	Husky	29 783	50.00
EL 1123	***Cupids***	***Statoil***	***201 951***	***75.00***
EL 1124	***Harpoon***	***Statoil***	***126 421***	***65.00***

2.2. Spatial and Temporal Boundaries

The ***spatial boundaries*** of the Project Area are shown in Figure 1.1. The coordinates of the Project Area (latitude and longitude in decimal degrees, NAD83) starting in the SW corner, proceeding in a clockwise direction, are as follows:

	Latitude (°N)	Longitude (°W)
1	46.0000000	-49.5000000
2	48.0000000	-49.5000000
3	48.0000000	-47.2488764
4	48.9998187	-47.2488646
5	48.9998138	-46.8738558
6	49.5000000	-46.8738484
7	49.5000000	-45.7500000
8	47.5000000	-45.7500000
9	47.5000000	-47.0000000
10	46.0000000	-47.0000000

At present, the defined Project Area includes space to accommodate a seismic vessel turning radius. The Study Area encompasses the Project Area and includes a 25 km buffer around that area.

The ***temporal boundaries*** of the proposed Project are from 2011-2019. However, seismic surveys will occur between 1 April and 31 October of any given year. The typical duration of a 2D or 3D survey, depending on the area to be surveyed could vary from 40 to >100 days within that temporal scope. The duration of a geohazard survey in support of a drilling program is about four to five days and could occur over a 9 to 11 day period including transit and weather down time. The option of carrying out geohazard surveys outside the April through October time frame noted above for 3D surveys will be considered in the EA to follow.

2.3. Project Overview

The proposed Project includes a ship-based seismic program starting with a 3D survey and a small number of 2D profiles in 2011 and other surveys (3D and potentially 2D or ocean bottom seismic) conducted as needed in subsequent years through 2019. This program may include repeat survey of some areas to evaluate changes in existing producing reservoirs over time typically called a “4D” survey. In addition, geohazard and potentially electromagnetic surveys will be conducted over potential drilling targets on current Statoil ELs and in future, yet-to-be-determined, locations as required during the program.

The 3D seismic survey vessel will tow a dual sound source (airgun array) and 10-14 streamer(s) composed of receiving accelerometers and hydrophones. The proposed survey in 2011 will likely have survey lines running northeast-southwest and spaced between 500 and 700 m apart, dependent on the vessel configuration. The 2D program will likely consist of lines running approximately east-west. The geohazard surveys will be conducted over a much shorter time frame using a smaller vessel and a combination of smaller scale seismic equipment, sonars, sparkers and boomers. Electromagnetic surveys may be conducted to better distinguish between hydrocarbons and water prior to drilling. Electromagnetic surveys entail towing an electrical source and measuring resistivity of the sea bed, typically using receivers placed on the seabed.

At the time of this EA writing, the seismic contractor for the proposed 2011 seismic program had not been selected. There is potential that at least one geohazard survey may occur in 2011 in the Jeanne d’Arc Basin area and two in the Flemish Pass area. The seismic component of the geohazard survey would not be conducted due to deep waters of the Flemish Pass. Any seismic vessel operated in 2011-2019 will be approved for operation in Canadian waters and be typical of the worldwide seismic fleet. A description of a representative seismic vessel and seismic equipment is provided below.

Mitigation procedures will include dedicated Marine Mammal Observer(s) (MMO); “soft-starts” or “ramp-ups” of the airgun array in order to minimize effects on marine life, particularly marine mammals and species at risk; a Fisheries Liaison Officer (FLO), and communication procedures to avoid conflicts with the fishery. The need for dedicated MMOs and FLOs for the more limited temporal and geographically scoped geohazard surveys in areas of limited fishing activity are evaluated and addressed in the following EA.

2.3.1. Objectives and Rationale

The objectives of the Project are to determine the presence and likely locations of geological structures that might contain hydrocarbon deposits. The 3D data are needed to provide higher resolution and quality images than are available from 2D surveys which use more widely spaced seismic lines and only one streamer. In general, 2D surveys are used to determine areas where precise and detailed 3D surveys should be done. Results of 3D surveys are then used to find potential locations for exploration drilling. In addition, 4D surveys may be conducted to assess the changes in a geological structure that have taken place over time. These 4D data are particularly useful for determining the behaviour of a reservoir in the production phase.

Once a potential drilling site is located it is standard offshore industry procedure, and a requirement of the C-NLOPB, that a well site/geohazard survey be conducted. The purpose of a geohazard survey is to identify, and thus avoid, any potential shallow drilling hazards such as steep and/or unstable substrates or pockets of "shallow gas". Also, a geohazard survey will check for seabed obstructions (manmade or natural), including boulders, shallow gas hydrates and assess general seabed conditions.

2.3.2. Alternatives to the Project, Alternatives within the Project

Existing 2D seismic data indicate structures that may contain significant volumes of producible hydrocarbons. These existing seismic data, while useful, are insufficient to determine exact structural size and internal complexity. Acquisition of new 3D seismic data is required to determine if exploration drilling is warranted.

Electromagnetic surveys, which may occur during the temporal scope of this assessment subject to approval of an EA amendment as described previously, are typically conducted over small target areas and are supplemental to 3D seismic data. Through measurements of resistivity, geophysicists are able to discriminate petroleum from water if the reservoir structure is known, and thus increase drilling success rates.

Statoil has made commitments to pursue exploration activities on its exploration licenses in Jeanne d'Arc and Flemish Pass basins. A 3D seismic survey is a standard precursor to offshore exploratory drilling. It better defines the target subsurface geological formations believed to contain hydrocarbon resources, lessens the chances of expending resources "drilling dry holes", and increases the overall safety of the drilling activity. Accordingly, there is no alternative to the proposed 3D survey program other than to incur the financial penalties attendant on not fulfilling Statoil's exploration commitments and to explore for oil and gas elsewhere.

As the geohazard surveys are a regulatory requirement of the C-NLOPB and a safety requirement for drilling operations, there is no alternative to them *per se*. An alternative would be to not drill the well and thus forgo the energy and economic benefits that would accrue to Statoil and partners, the province of Newfoundland and Labrador, and Canada.

Viable alternatives within the seismic and geohazard programs are essentially the choices between different contractor's ships and survey equipment which will be evaluated though the bid evaluation process. In addition, there is potential that Statoil may conduct electromagnetic surveys in the Project

Area similar to those conducted in the Orphan Basin (e.g., Buchanan et al. 2006). As noted previously, if electromagnetic surveys are planned an amendment to this environmental assessment will be submitted.

2.3.3. Project Scheduling

In 2011, it is anticipated that the 3D seismic survey will be at least 40 days in duration and the survey is expected to commence in June. Prior to the start of the 3D program, it is anticipated that a small 2D program (three days duration) will occur adjacent to the "2011 Proposed 3D Seismic Area". In 2012-2019, seismic surveys may occur between 1 April and 31 October and the program duration is estimated at 40 to >100 days. There is potential that at least one geohazard survey may occur in 2011. As many as five geohazard surveys per year may occur in 2011-2019, with a total individual survey duration of 9 to 11 days (including 4 to 5 days of data acquisition) per survey.

2.3.4. Site Plans

The area (1,675 km^2) where full-fold seismic data are proposed to be acquired in 2011 is shown in Figure 1.1 (Potential 3D Seismic Area 2011). Water depth in the survey area ranges from approximately 2,500 to 3,000 m. The proposed survey in 2011 will likely have survey lines running northeast-southwest and spaced between 500 and 700 m apart. The final dimensions of the 2011 survey area are subject to final survey planning; however, surveying will focus on EL1123 (Figure 1.1).

Geohazard surveys will be conducted at exploratory drill sites which will be identified in future years. For potential jack-up drill rig sites, geohazard data will be acquired along transects spaced 50 m apart. Transects will be spaced 250 m apart with tie lines at 500 m at potential semi-submersible drill rig sites. Survey grids (estimated at 5 km x 5 km) will be centered at potential drill sites.

2.3.5. Personnel

A seismic vessel can typically accommodate 40-60 personnel. The largest seismic vessels under consideration by Statoil could potentially accommodate up to 60 personnel. Personnel on seismic vessels typically include Proponent's representatives (i.e., Statoil), the vessel owner/operator (ship's officers and marine crew), and technical and scientific personnel from the main seismic contractor. The seismic vessel will have a FLO and a MMO(s) on board, as well as a Statoil representative(s) that serves as Client Quality Control and Processing Quality Control. All project personnel will have all of the required certifications as specified by relevant Canadian legislation and the C-NLOPB.

Total crew on board a geohazard vessel will likely be 15 (ship's crew), and 15 (technical), and one MMO[1] for a total of 30 + individuals.

[1] If space availability aboard the geohazard vessel is limited, one of the ship's crew trained in marine mammal and seabird identification and data collection protocols will perform the duties of a MMO.

2.3.6. Seismic Vessel

Statoil may charter a vessel specifically for its use or utilize a seismic vessel already operational in East Coast waters. Vessel specifics will be provided once the contractors are selected. Most, if not all, likely survey vessels have diesel-electric propulsion systems (main and thrusters) and operate on marine diesel or marine gas-oil. A typical example of a seismic vessel is the M/V *Western Patriot* which is 78 m long and 17 m wide with a mean draft of 5.9 m. Its maximum speed is 13 knots and it transits at a speed of 11.5 knots. The *Western Patriot* operates a main engine (two Rolls Royce Bergen/BRM 6: 5300 kW) and has a bow thruster (590 kW). It operates a Simrad EA500 echosounder that operates at 18 kHz and 200 kHz as well as a Furuno FE 680/50. The ship will deploy a workboat to repair streamers when necessary.

2.3.7. Seismic Energy Source Parameters

The seismic energy source will be comprised of individual airguns arranged in an array. The airgun array for the *Western Patriot* is described here to provide an example of a typical seismic source as used on the East Coast. [The seismic array size (number of airguns, total volume) and configuration will vary depending on the contractor.] Two 5085 in^3 arrays of 24 Bolt airguns per array are used by the *Western Patriot*. The largest airgun used is 290 in^3 and the smallest 105 in^3. The two 5085 in^3 airgun arrays are typically activated alternately (flip-flop arrangement) along the survey lines with a shotpoint interval of 25 m. The airgun arrays are typically operated at a depth of 5 to 8 m below the water surface and are towed up to 400 m behind the seismic vessel. Survey speed is around 4.5 knots (8.3 km/h). Airguns typically are operated at 2000 psi and the estimated source level[2] of the array is 109.9 bar-m (~255 dB re 1 µPa (0-p)). The airguns in the array are strategically arranged to direct most of the energy vertically rather than sideways (see Appendix C *in* LGL (2007a)) for a review of airgun sound characteristics).

2.3.8. Seismic Streamers

Typically 10 to 14 streamers (strings of hydrophone sound receivers), each up to 8 km in length, are towed behind the seismic vessel to record the airgun pulses during 3D seismic surveys. [Individual stand alone 2D profiles might be acquired by the 3D vessel without any change of configuration or by a different vessel towing only one streamer.] Once again, the *Western Patriot* is used as a representative example for the purposes of this EA. The *Western Patriot* tows eight 5 km streamers and the streamers are Sentry and Guardian Solid Streamers (Thompson Marconi). The streamers are separated by 100 m for a total spread of 700 m and are typically deployed at a depth of 8 to 10 m.

It is possible that in 2011-2019 streamers may be fluid-filled but Statoil will through its evaluation criteria for the Tender documents favour solid streamer vessels. Fluid-filled streamers control buoyancy with a fluid called Isopar-M. Isopar-M predominantly consists of isoparaffinic hydrocarbons (C12-C15). In a typical Isopar filled streamer, each 100 m hydrophone section contains 11.7 L of Isopar divided amongst 78 hydrophone pockets. Each hydrophone pocket contains 150 mL of Isopar and is isolated and completely sealed from other pockets. This isolation of pockets greatly reduces the chances of releasing large amounts of fluid even in the event of a major streamer accident.

[2] Includes frequencies up to 128 Hz.

2.3.9. Geohazard Vessel and Equipment

Geohazard surveys will be conducted from a vessel similar to the MV *Anticosti* or *Maersk Placentia*. The *Anticosti* is a 54 m long offshore research vessel/tug owned by Cape Harrison Marine of St. John's. Vessels presently approved and operating on the East Coast on other offshore programs will be utilized. Vessel specifics will be provided once the contractors are selected. Most, if not all likely survey vessels have diesel-electric propulsion systems (main and thrusters) and operate on marine diesel.

Typically such a program involves acquisition of high resolution seismic, side scan sonar, sub-bottom profile, and bathymetric data over defined area (s) where jack-up and semi-submersible drilling rigs may potentially be used. These surveys use closer line spacings, smaller equipment and lower pressures, and over a shorter time period (i.e., several days) compared to 3-D seismic programs. Survey speed will be on the order of four to five knots.

For potential jack-up rig sites, geohazard data will be acquired along transects spaced 50 m apart. Transects will be spaced 250 m apart with tie lines at 500 m at potential semi-submersible drill rig sites. Survey grids (typically 10 km x 10 km) will be centered at potential drill sites.

From an operational perspective, the following text summarizes the typical equipment to be used during surveying. However, it should be noted that equipment may vary depending on contractor selection. If equipment specifics differ from those included below, details will be provided once the contractors are selected.

2.3.9.1. Geohazard Seismic Data

High-resolution multi-channel seismic data will be acquired during geohazard surveys with an airgun array with a total volume of 160 in^3, a 96-channel streamer (6.25 m group and shot interval, 600 m active length), and a TTS 2+ digital recording system. Data will be acquired to two seconds depth, sampled at one millisecond.

The seismic source will be comprised of four airguns, each of 40 in^3 capacity. They will be deployed within a ladder array, approximately 30 m off the stern of the vessel, and at a depth of 3 m. The compressed air is provided by a diesel-powered compressor on deck. The maximum output from this array has a peak to peak value of 17.0 Bar metres. This equates to a source level (at 1 m) of 244.6 dB re 1µPa (peak to peak), or 238 dB re 1µPa (zero to peak).

The streamer will be towed from the port quarter of the vessel. A tail buoy will be used, equipped with a radar reflector and strobe light. Total streamer length will be approximately 650 m.

2.3.9.2. Surficial Data

Huntec Deep Tow System.—A Huntec Deep Tow System (DTS) will be deployed from the stern of the survey vessel, through an "A" Frame. This system has been proven to be the most effective at providing high resolution sub-bottom profiles from the Grand Banks. The system is towed within the water column, at a distance of between 20 and 40 m off the seabed. The system will be approximately 150 m behind the survey vessel (dependent on cable deployed, water depth and vessel speed).

The Huntec DTS uses a “broadband” boomer acoustic source, with frequency bandwidth from 500 Hz to 6 kHz. Power output is typically 500 Joules, but may be increased to 1 kJ if necessary. Rise time of the pulse is less than 0.1 millisecond. The boomer derived pulse is primarily restricted to a 60º cone. Maximum peak to peak amplitude is 221 dB re 1 μPa at 1 m.

Side-scan Sonar.—Seabed imagery, for the clearance survey, will be acquired with a digital, dual frequency (105 kHz and 390 kHz) side-scan sonar system. The sonar source level for 390 kHz is 216 dB re 1 μPa at 1 m (zero to peak) and for 105 kHz is 221 dB re 1 μPa at 1 m (zero to peak). The activation rate of the side-scan sonar is 3.3 times per second at 200 m range. The beamwidth is: horizontal, 1.2º and 0.5º for the 105 kHz and 390 kHz frequencies, respectively. A 50º arc is swept perpendicular to the survey transect. Data will be logged to tape and printed in hard copy for on-board assessment. Geo-referenced data will be utilized to create a digital side scan sonar mosaic for inclusion in survey reports.

Echo Sounders.—A Reson 8101 multi-beam echo sounder will be operated to acquire bathymetric data. Power output levels are similar to a typical echo sounder commonly used on the Grand Banks. The system operates at a frequency of 240 kHz and the source level is 207 dB re 1 uPa at 1 m (zero to peak) and its sounding rate may be ~4 to 6 times per second. The multibeam echo sounder covers 1.5º per beam and 101 beams cover a 150º arc perpendicular to the survey transect.

A single-beam echosounder will be operated to provide quality control of the data acquired from the multi-beam echosounder. The single-beam echosounder operates at 24 kHz and 200 kHz (dual frequency capable) and the source levels are 213 dB re 1 uPa at 1 m (zero to peak) and 209 dB re 1 uPa at 1 m (zero to peak) for 24 kHz and 200 kHz frequencies, respectively. The sounding rate of this source will be typically two times per second. The single-beam echosounder derived pulse is primarily restricted to a 9º (200 Hz) and a 24º (24 kHz) conical beam.

Magnetometer.—In the event that potential debris is identified by the side scan or multi-beam systems, a proton magnetometer will be utilized. This system is towed behind the vessel, 5 to 10 m above the seabed, and emits a low power electromagnetic field.

Camera and Sediment Sampler.—A camera system and sediment sampler will be deployed at a number of locations across the site, for the purposes of groundtruthing the geophysical data. Surficial sediment samples (of approximately 0.7 L in size) will be described on board by a geologist, and stored in sample bags for subsequent processing. The camera will be lowered to an elevation of one metre or more above the seabed as the vessel drifts across the intended sites.

2.3.10. Logistics and Support

Offshore seismic operations will be supported by a picket and supply vessel and potentially a helicopter.

2.3.10.1. Picket Vessel

The seismic ship may be accompanied by a picket vessel with responsibilities for communications with other vessels (primarily fishing vessels) that may be operating in the area and for scouting ahead looking for hazards. The geohazard vessel will not be accompanied by a picket vessel.

2.3.10.2. Supply Vessel

Heavy re-supply (including water, food, parts and fuel) to the seismic vessel will be conducted by offshore supply vessel throughout the duration of the program. Given the short duration of a typical geohazard survey, re-supply is not anticipated. Supply vessels will be typical of those that regularly service Hibernia, Terra Nova and White Rose. A typical supply vessel on the Grand Banks is crewed by about 6 to 12 marine qualified personnel.

2.3.10.3. Helicopter

The larger seismic vessels are usually equipped with a helicopter platform and helicopters are often used for crew changes and light re-supply. Survey contractors will be responsible for all arrangements with respect to helicopter transportation. Helicopter operations will be according to safety requirements as specified by relevant authorities, including the C-NLOPB.

2.3.10.4. Shore Base

Statoil maintains an office in St. John’s. Seismic contractors may prefer to crew change or re-supply in St. John’s or other existing Newfoundland ports, presumably on the Avalon Peninsula because of proximity to the Project Area. No new shore base facilities will be established as part of this Project.

2.3.11. Waste Management

Wastes produced from the seismic, geohazard, supply and picket vessels, including grey and black water, bilge water, deck drainage, discharges from machinery spaces and hazardous and non-hazardous waste material will be managed in accordance with MARPOL and with Statoil’s waste management plan. The contracted vessels policies and procedures will be reviewed against the Statoil Plan. Statoil’s waste management plan will be filed with the C-NLOPB in support of the *Authorization to Conduct a Geophysical Program*. A licensed waste contractor will be used for any waste returned to shore.

2.3.12. Air Emissions

Air emissions will be those associated with standard operations for marine vessels in general, including the seismic vessel, picket vessel, geohazard and supply vessel. There are no anticipated implications for the health and safety of workers on these vessels.

2.3.13. Accidental Events

In the unlikely event of the accidental release of hydrocarbons during the Project, Statoil and its seismic and geohazard survey contractor will implement the measures outlined in its oil spill response plan which will be filed with the C-NLOPB in support of the *Authorization to Conduct a Geophysical Program* application. In addition, Statoil has emergency response plans in place which will be bridged with the seismic (and geohazard) contractor's response plans prior to commencement of the seismic program.

2.4. Mitigation

Mitigation measures are detailed throughout the EA. The measures are reviewed and summarized in Section 5.8.

3.0 Physical Environment

The Scoping Document required that the EA include a review of the meterological and oceanographic characteristics, including extreme conditions, to provide the basis for assessing the effects of the environment on the Project. A detailed description of met-ocean conditions in the Study and Project areas, and methodologies used, are contained in the report by Oceans (2011). A summary of the most relevant climatology (Section 3.2), physical oceanography (Section 3.3), and ice/iceberg (Section 3.4) information is provided below.

3.1. Bathymetry and Geology

As indicated in the Orphan Basin Strategic Environmental Assessment (LGL 2003) and the White Rose Comprehensive Study (Husky 2000), the topography of the Study Area is highly diverse and includes at least five distinct types as characterized by depth, location and physiography: (1) Jeanne d'Arc Basin (depths ≤200 m) in the southwestern portion of the Study Area; (2) northeast Newfoundland Shelf Slope and Flemish Cap Shelf (depths >200 to 2000 m) throughout middle/eastern portion of the Study Area; (3) Orphan Basin proper (depths 2000 to >3000 m) in the northern portion of the Study Area; and (4) the Flemish Pass (depths >1000 m). The characterization of surficial sediment in the Study Area ranges from fine (mud and clay) to extremely coarse (boulders and bedrock).

3.2. Climatology

Every marine seismic survey program is influenced by weather conditions both from routine operational and environmental safety perspectives. During routine activities, data quality and hence, survey time on site can be affected by weather, particularly wind and wave conditions. This section provides a very general overview of climatic conditions in the Study Area with a more detailed description of extreme events. The reader is referred to Section 2 of Oceans (2011) for more details.

3.2.1. Weather Systems

The Study Area including the Northeast Grand Banks, Flemish Pass and the southern Orphan Basin experiences weather conditions typical of a marine environment with the surrounding waters having a moderating effect on temperature. In general, marine climates experience cooler summers and milder winters than continental climates and have a much smaller annual temperature range. Furthermore, a marine climate tends to be fairly humid, resulting in reduced visibilities, low cloud heights, and receives significant amounts of precipitation.

The climate of the Study Area is very dynamic, being largely governed by the passage of high and low pressure circulation systems. These circulation systems are embedded in, and steered by, the prevailing westerly flow that typifies the upper levels of the atmosphere in the mid-latitudes, which arises because of the normal tropical to polar temperature gradient. The mean strength of the westerly flow is a function of the intensity of this gradient, and as a consequence is considerably stronger in the winter months than during the summer months, due to an increase in the south to north temperature gradient. [Meteorological convention defines seasons by quarters; e.g., winter is December, January, February, etc.]

At any given time, the upper level flow is a wave-like pattern of large and small amplitude ridges and troughs. These ridges and troughs tend to act as a steering mechanism for surface features and therefore their positions in the upper atmosphere determine the weather at the earth's surface. Upper ridges tend to support areas of high pressure at the surface, while upper troughs lend support to low pressure developments. The amplitude of the upper flow pattern tends to be greater in winter than summer, which is conducive to the development of more intense storm systems.

During the winter months, an upper level trough tends to lie over Central Canada and an upper ridge over the North Atlantic resulting in three main storm tracks affecting the region: one from the Great Lakes Basin, one from Cape Hatteras, North Carolina and one from the Gulf of Mexico. These storm tracks, on average, bring eight low pressure systems per month over the area.

Frequently, intense low pressure systems become 'captured' and slow down or stall off the coast of Newfoundland and Labrador. This may result in an extended period of little change in conditions that may range, depending on the position, overall intensity and size of the system, from the relatively benign to heavy weather conditions.

Rapidly deepening storms are a problem south of Newfoundland in the vicinity of the warm water of the Gulf Stream. Sometimes these explosively deepening oceanic cyclones develop into a "weather bomb"; defined as a storm that undergoes central pressure decreases greater than 24 mb over 24 hours. Hurricane force winds near the center, the outbreak of convective clouds to the north and east of the center during the explosive stage, and the presence of a clear area near the center in its mature stage (Rogers and Bosart 1986) are typical of weather bombs. After development, these systems will either move across Newfoundland or near the southeast coast producing gale to storm force winds from the southwest to south over the area.

There is a general warming of the atmosphere during spring due to increasing heat from the sun. This spring warming results in a decrease in the north-south temperature gradient. Due to this weaker temperature gradient during the summer, storms tend to be weaker and not as frequent. Furthermore, the weaker tropical-to-polar temperature gradient in the summer results in the storm tracks moving further north. With the low pressure systems passing to the north of the region, the prevailing wind direction during the summer months is from the southwest to south. As a result, the incidences of gale or storm force winds are relatively infrequent over Newfoundland during the summer.

3.2.2. Extreme Analysis

An analysis of extreme wind and waves was performed using the MSC50 data set. This data set was determined to be the most representative of the available data sets, as it provides a continuous 52-year period of 1 hourly data for the Project Area. The extreme value analysis for wind speeds was carried out using the peak-over-threshold method. For the extreme wave analysis, two methods were used; the peak-over-threshold method and the joint probability method (Oceans 2011).

After considering four different distributions, the Gumbel distribution was chosen to be the most representative for the peak-over-threshold method as it provided the best fit to the data. Since extreme values can vary, depending on how well the data fits the distribution, a sensitivity analysis was carried out to determine how many storms to use in the analysis.

The number of storms determined to provide the best fit annually and monthly for each of the four grid points used in the analyses (see Figure 3.1) are presented in Table 3.1.

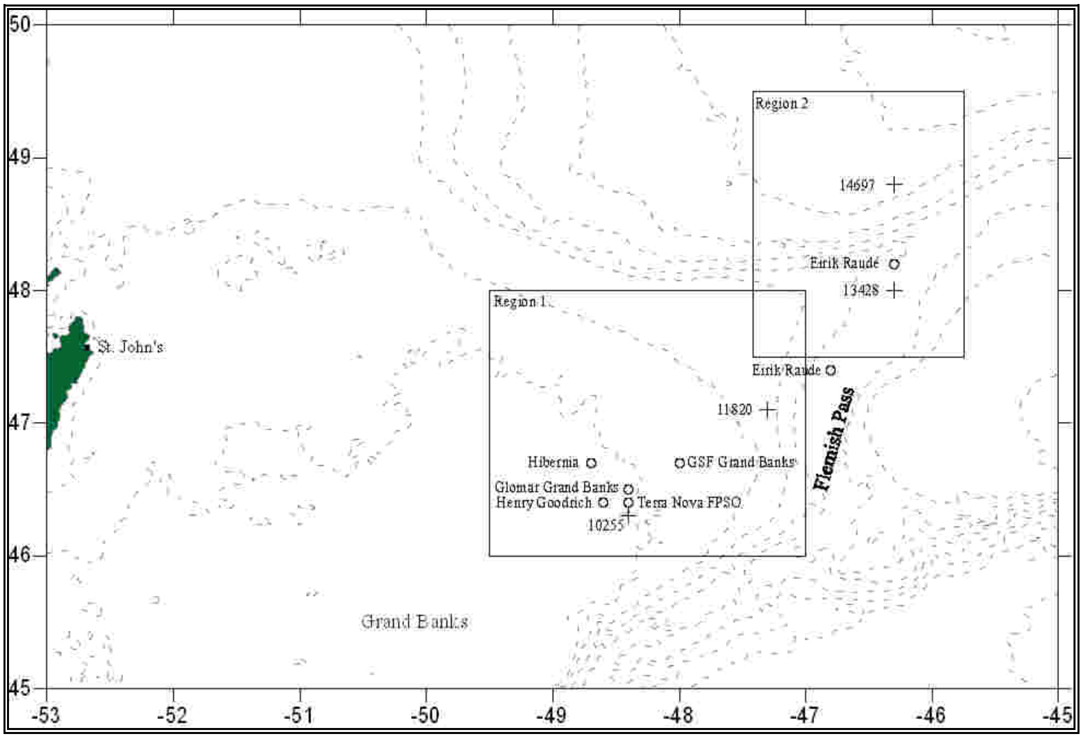


Figure 3.1. Location of the grid points (10255, 11820, 13428, and 14697) and regions used in the physical environment analyses.

Table 3.1. Number of storms providing best fit for extreme value analysis of winds and waves.

Region	Grid Point No.	Parameter	Annually	Monthly
1	10255	Wind	314	71
		Wave	323	73
	11820	Wind	232	56
		Wave	234	56
2	13428	Wind	284	66
		Wave	227	55
	14697	Wind	265	62
		Wave	247	60

3.2.2.1. Extreme Value Estimates for Winds from the Gumbel Distribution

The extreme value estimates for wind were calculated using Oceanweather's Osmosis software program for the return periods of 1-year, 10-years, 25-years, 50-years and 100-years. The analysis used hourly wind values for the reference height of 10 m above sea level. These values were converted to 10-minute and 1-minute wind values using a constant ratio of 1.06 and 1.22, respectively (U.S. Geological Survey 1979).

The calculated annual and monthly wind values for 1-hour, 10-minutes and 1-minute in Region 1, are presented in Tables 3.2 to 3.4. The annual 100-year extreme 1-hour wind speed was determined to be 31.5 m/s at Grid Point 10255 and 32.2 m/s at Grid Point 11820. Monthly, the highest extreme winds occur during February at Grid Points 10255 and 11820 with extreme wind estimates of 30.7 m/s and 31.2 m/s, respectively.

Table 3.2. 1-hr extreme wind speed estimates (m/s) for return periods of 1, 10, 25, 50 and 100 years in Region 1.

	GridPoint #10255					GridPoint #11820				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	22.1	25.6	26.7	27.6	28.5	22.6	26.4	27.4	28.6	29.1
February	21.9	26.8	28.3	29.5	30.7	21.7	27.3	28.9	30.1	31.2
March	20.0	24.5	25.9	27.0	28.1	19.6	25.4	27.0	28.3	29.5
April	18.0	22.1	23.5	24.5	25.5	17.8	22.7	24.0	25.1	26.1
May	15.3	19.2	20.5	21.4	22.4	15.2	20.3	21.7	22.8	23.8
June	14.1	17.6	18.8	19.7	20.5	13.9	18.2	19.5	20.4	21.3
July	13.0	17.1	18.4	19.4	20.4	12.6	17.0	18.2	19.1	20.0
August	13.7	20.6	22.9	24.6	26.3	12.4	20.7	23.0	24.8	26.5
September	16.7	22.0	23.8	25.1	26.3	16.5	22.3	24.0	25.2	26.4
October	17.9	23.3	25.1	26.4	27.7	17.7	23.8	25.6	26.9	28.2
November	19.6	24.4	26.0	27.1	28.3	18.9	24.8	26.5	27.7	29.0
December	21.4	26.2	27.8	29.0	30.1	21.4	26.8	28.3	29.5	30.6
Annual	24.7	28.1	29.5	30.5	31.5	25.4	28.8	30.2	31.2	32.2

Table 3.3. 10-minute extreme wind speed (m/s) estimates for return periods of 1, 10, 25, 50 and 100 years in Region 1.

	GridPoint #10255					GridPoint #11820				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	23.4	27.1	28.3	29.3	30.2	23.9	27.9	29.1	30.3	30.8
February	23.2	28.4	30.0	31.3	32.6	23.0	28.9	30.6	31.9	33.1
March	21.2	25.9	27.5	28.7	29.8	20.7	26.9	28.6	29.9	31.2
April	19.1	23.5	24.9	26.0	27.1	18.9	24.0	25.5	26.6	27.7
May	16.2	20.3	21.7	22.7	23.7	16.1	21.5	23.0	24.1	25.2
June	14.9	18.7	19.9	20.9	21.8	14.7	19.3	20.6	21.6	22.6
July	13.7	18.1	19.5	20.6	21.6	13.4	18.0	19.3	20.3	21.2
August	14.5	21.8	24.3	26.1	27.9	13.1	21.9	24.4	26.3	28.1
September	17.7	23.3	25.2	26.6	27.9	17.4	23.6	25.4	26.7	28.0
October	18.9	24.7	26.6	28.0	29.4	18.8	25.3	27.1	28.5	29.9
November	20.7	25.8	27.5	28.8	30.0	20.1	26.3	28.1	29.4	30.7
December	22.7	27.8	29.4	30.7	31.9	22.7	28.4	30.0	31.3	32.5
Annual	26.2	29.8	31.2	32.3	33.4	26.9	30.5	32.0	33.0	34.1

Table 3.4. 1-minute extreme wind speed (m/s) estimates for return periods of 1, 10, 25, 50 and 100 years in Region 1.

	GridPoint #10255					GridPoint #11820				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	26.9	31.2	32.6	33.7	34.7	27.5	32.2	33.5	34.8	35.5
February	26.7	32.6	34.6	36.0	37.5	26.5	33.3	35.2	36.7	38.1
March	24.4	29.9	31.6	33.0	34.3	23.9	30.9	33.0	34.5	36.0
April	22.0	27.0	28.7	29.9	31.1	21.8	27.6	29.3	30.6	31.8
May	18.7	23.4	25.0	26.1	27.3	18.6	24.7	26.5	27.8	29.1
June	17.2	21.5	22.9	24.0	25.1	16.9	22.2	23.7	24.9	26.0
July	15.8	20.8	22.4	23.7	24.9	15.4	20.7	22.2	23.3	24.4
August	16.7	25.1	27.9	30.0	32.1	15.1	25.2	28.1	30.2	32.4
September	20.4	26.9	29.0	30.6	32.1	20.1	27.2	29.2	30.7	32.2
October	21.8	28.4	30.6	32.2	33.8	21.6	29.1	31.2	32.8	34.4
November	23.9	29.7	31.7	33.1	34.6	23.1	30.3	32.3	33.8	35.3
December	26.2	32.0	33.9	35.3	36.7	26.1	32.7	34.6	36.0	37.4
Annual	30.1	34.3	36.0	37.2	38.4	30.9	35.2	36.8	38.0	39.2

The calculated annual and monthly wind speed values for 1-hour, 10-minutes and 1-minute return periods in Region 2 are presented in Tables 3.5 to 3.7. The annual 100-year extreme 1-hour wind speed was determined to be 33.2 m/s at Grid Point 13428 and 33.4 m/s at Grid Point 14697. Monthly, the highest extreme winds occur during February at Grid Point 13428 with extreme wind estimates of 32.7m/s. For Grid Point 14697, December has the highest 1-hour extreme wind estimate of 32.8 m/s.

Table 3.5. 1-hr extreme wind speed estimates (m/s) for return periods of 1, 10, 25, 50 and 100 years in Region 2.

	GridPoint #13428					GridPoint #14697				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	23.1	27.0	28.2	29.2	30.1	23.2	26.8	27.9	28.8	29.6
February	22.8	28.3	30.0	31.4	32.7	23.0	28.3	30.0	31.2	32.5
March	20.7	25.8	27.4	28.6	29.9	20.8	26.4	28.1	29.4	30.7
April	18.7	22.8	24.2	25.2	26.2	18.9	22.9	24.2	25.1	26.1
May	16.4	21.2	22.7	23.9	25.0	16.5	21.3	22.8	23.9	25.1
June	14.8	18.8	20.0	21.0	21.9	15.1	18.9	20.0	20.9	21.7
July	13.5	16.7	17.8	18.5	19.3	13.4	17.1	18.3	19.1	20.0
August	13.7	20.5	22.7	24.4	26.0	13.7	20.2	22.2	23.7	25.2
September	17.5	23.6	25.6	27.1	28.5	17.8	23.0	24.6	25.8	27.0
October	18.8	24.3	26.0	27.3	28.6	18.9	24.8	26.8	28.2	29.6
November	20.4	25.2	26.7	27.8	29.0	20.7	25.3	26.7	27.7	28.7
December	22.5	27.9	29.7	31.0	32.3	22.3	28.3	30.1	31.5	32.8
Annual	26.0	29.7	31.1	32.2	33.2	26.2	29.9	31.3	32.3	33.4

Table 3.6. 10-minute extreme wind speed (m/s) estimates for return periods of 1, 10, 25, 50 and 100 years in Region 2.

	GridPoint #13428					GridPoint #14697				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	24.5	28.6	29.9	30.9	31.9	24.6	28.4	29.6	30.5	31.4
February	24.2	30.0	31.8	33.2	34.6	24.3	30.0	31.8	33.1	34.4
March	21.9	27.3	29.1	30.4	31.6	22.0	28.0	29.8	31.2	32.5
April	19.8	24.2	25.6	26.7	27.7	20.0	24.3	25.6	26.6	27.7
May	17.4	22.4	24.1	25.3	26.5	17.5	22.6	24.2	25.4	26.6
June	15.7	19.9	21.2	22.2	23.2	16.0	20.0	21.2	22.1	23.0
July	14.4	17.7	18.8	19.6	20.4	14.2	18.1	19.3	20.3	21.1
August	14.5	21.8	24.1	25.8	27.5	14.5	21.4	23.5	25.1	26.7
September	18.5	25.0	27.1	28.7	30.2	18.8	24.4	26.1	27.3	28.6
October	19.9	25.7	27.6	29.0	30.3	20.1	26.3	28.4	29.9	31.4
November	21.6	26.7	28.3	29.5	30.7	22.0	26.8	28.2	29.4	30.5
December	23.8	29.6	31.4	32.8	34.2	23.6	29.9	31.9	33.3	34.8
Annual	27.5	31.4	32.9	34.1	35.2	27.7	31.6	33.1	34.3	35.4

Table 3.7. 1-minute extreme wind speed (m/s) estimates for return periods of 1, 10, 25, 50 and 100 years in Region 2.

	GridPoint #13428					GridPoint #14697				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	28.2	32.9	34.4	35.6	36.7	28.3	32.7	34.1	35.1	36.1
February	27.8	34.5	36.6	38.2	39.8	28.0	34.6	36.6	38.1	39.6
March	25.2	31.5	33.5	34.9	36.4	25.3	32.2	34.3	35.9	37.4
April	22.8	27.9	29.5	30.7	31.9	23.0	27.9	29.5	30.7	31.8
May	20.0	25.8	27.7	29.1	30.5	20.1	26.0	27.9	29.2	30.6
June	18.1	22.9	24.4	25.6	26.7	18.5	23.0	24.4	25.5	26.5
July	16.5	20.4	21.7	22.6	23.5	16.4	20.9	22.3	23.3	24.3
August	16.7	25.0	27.7	29.7	31.7	16.7	24.6	27.1	28.9	30.8
September	21.3	28.8	31.2	33.0	34.8	21.7	28.0	30.0	31.5	32.9
October	22.9	29.6	31.7	33.3	34.9	23.1	30.3	32.6	34.4	36.1
November	24.8	30.7	32.6	34.0	35.3	25.3	30.8	32.5	33.8	35.1
December	27.4	34.0	36.2	37.8	39.4	27.2	34.5	36.7	38.4	40.0
Annual	31.7	36.2	37.9	39.2	40.5	31.9	36.4	38.1	39.5	40.8

3.2.2.2. Extreme Value Estimates for Waves from a Gumbel Distribution

The annual and monthly extreme value estimates for significant wave height for return periods of 1-year, 10-years, 25-years, 50-years and 100-years in Region 1 are given in Table 3.8. The annual 100-year extreme significant wave height is 15.2 m for Grid Point 10255 and 15.8 m for Grid Point 11820. The highest extreme significant wave height occurs during February with an extreme height of 14.9 m at Grid Pont 10255 and 15.8 m at Grid Point 11820.

During a storm event on 8 January 2007, a maximum individual wave height of 22.6 m was recorded by a waverider in the Terra Nova field. This is greater than the January maximum 10-year return period estimate of 21.8 m for grid point 10255, which is the closest grid point to the Terra Nova waverider; however, it is less than the 25-year return period estimate of 23.7 m. The significant wave height during the January 2007 storm event was 9.7 m.

Table 3.8. Extreme significant wave height estimates (m) for return periods of 1, 10, 25, 50 and 100 years in Region 1.

	GridPoint #10255					GridPoint #11820				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	8.8	11.9	12.9	13.7	14.4	9.4	12.5	13.4	14.1	14.8
February	8.3	11.9	13.1	14.0	14.9	8.5	12.8	14.0	14.9	15.8
March	7.1	10.1	11.1	11.8	12.6	7.1	10.4	11.4	12.1	12.8
April	5.8	8.6	9.5	10.2	10.9	5.5	9.1	10.2	10.9	11.7
May	4.6	6.9	7.7	8.3	8.9	4.4	7.7	8.6	9.3	10.0
June	3.7	5.8	6.5	7.0	7.6	3.4	6.3	7.2	7.8	8.4
July	3.4	5.3	6.0	6.4	6.9	3.1	5.5	6.2	6.7	7.2
August	3.8	6.2	7.0	7.6	8.2	3.4	6.4	7.2	7.9	8.5
September	5.3	8.5	9.6	10.4	11.2	5.1	9.2	10.4	11.3	12.2
October	6.2	9.6	10.7	11.6	12.4	5.9	10.5	11.8	12.8	13.7
November	7.4	10.3	11.2	11.9	12.7	7.6	11.1	12.2	13.0	13.8
December	8.6	11.6	12.5	13.2	14.0	9.0	12.4	13.4	14.1	14.8
Annual	10.5	12.9	13.8	14.5	15.2	11.3	13.6	14.5	15.1	15.8

The maximum individual wave heights and extreme associated peak periods are presented Tables 3.9 and 3.10, respectively. Maximum individual wave heights and the extreme associated peak periods peak during February for both points.

Table 3.9. Extreme maximum wave height estimates for return periods of 1, 10, 25, 50 and 100 years in Region 1.

	GridPoint #10255					GridPoint #11820				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	16.4	21.8	23.7	25.0	26.4	17.3	23.0	24.6	25.8	27.0
February	15.5	22.1	24.3	25.9	27.5	15.9	23.7	25.9	27.5	29.2
March	13.5	19.3	21.2	22.6	24.0	13.1	19.2	20.9	22.2	23.5
April	11.0	15.9	17.5	18.7	19.9	10.3	16.9	18.8	20.1	21.5
May	8.6	13.9	15.7	17.0	18.3	8.2	14.9	16.9	18.3	19.7
June	7.1	11.0	12.3	13.3	14.3	6.6	11.7	13.1	14.2	15.3
July	6.4	9.9	11.1	12.0	12.8	5.9	10.3	11.5	12.4	13.3
August	7.2	11.6	13.0	14.1	15.2	6.7	11.6	13.0	14.1	15.1
September	10.3	16.0	17.9	19.4	20.8	9.4	16.8	18.9	20.5	22.0
October	11.7	17.8	19.8	21.3	22.8	11.0	19.2	21.5	23.3	25.0
November	13.9	19.1	20.7	22.0	23.3	14.0	20.4	22.3	23.8	25.2
December	16.4	21.7	23.5	24.8	26.1	16.8	22.9	24.7	26.0	27.3
Annual	19.5	23.8	25.5	26.7	28.0	20.9	25.1	26.7	27.9	29.2

Table 3.10. Extreme associated peak period estimates for return periods of 1, 10, 25, 50 and 100 years in Region 1.

	GridPoint #10255					GridPoint #11820				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	12.6	14.3	14.8	15.1	15.4	12.9	14.7	15.2	15.5	15.9
February	12.2	14.4	15.0	15.5	15.9	12.2	14.9	15.6	16.1	16.5
March	11.4	13.3	13.8	14.2	14.6	11.9	13.5	13.9	14.1	14.4
April	11.1	12.5	12.9	13.2	13.5	10.8	12.6	13.1	13.4	13.7
May	10.0	11.4	11.8	12.0	12.3	9.6	12.2	12.8	13.2	13.6
June	9.4	11.0	11.4	11.8	12.1	8.3	11.1	11.8	12.3	12.7
July	8.5	10.2	10.7	11.1	11.4	8.2	10.8	11.4	11.8	12.2
August	8.9	11.5	12.2	12.8	13.3	8.9	11.3	11.9	12.3	12.7
September	10.6	13.1	13.8	14.3	14.8	10.7	13.5	14.1	14.6	15.0
October	11.4	13.6	14.2	14.6	15.0	11.4	13.7	14.2	14.5	14.9
November	11.9	13.4	13.8	14.1	14.4	12.4	13.8	14.1	14.3	14.6
December	12.8	14.0	14.4	14.6	14.9	13.0	14.7	15.2	15.5	15.8
Annual	13.6	14.8	15.2	15.5	15.8	14.1	15.4	15.9	16.2	16.5

The annual and monthly extreme value estimates for significant wave height for return periods of 1-year, 10-years, 25-years, 50-years and 100-years in Region 2 are given in Table 3.11. The annual 100-year extreme significant wave height for Grid Point 13428 and Grid Point 14697 is 16.3 m and 16.4 m, respectively. The highest extreme significant wave height occurs during winter with an extreme height of 16.2 m in February at Grid Point 13428 and 15.9 m in December at Grid Point 14697.

Table 3.11. Extreme significant wave height estimates for return periods of 1, 10, 25, 50 and 100 years in Region 2.

	GridPoint #13428					GridPoint #14697				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	9.8	12.8	13.6	14.2	14.8	10.1	12.8	13.6	14.3	14.9
February	8.7	13.1	14.4	15.3	16.2	9.4	13.0	14.1	14.9	15.7
March	7.3	10.6	11.6	12.2	12.9	7.7	10.8	11.8	12.5	13.1
April	5.9	9.3	10.3	11.0	11.7	6.4	9.3	10.3	10.9	11.6
May	4.6	8.3	9.3	10.1	10.8	4.9	8.4	9.5	10.3	11.1
June	3.5	6.6	7.5	8.1	8.7	3.9	6.5	7.3	7.9	8.5
July	3.3	5.5	6.1	6.5	7.0	3.5	5.5	6.1	6.5	6.9
August	3.5	6.4	7.3	7.9	8.5	3.9	6.1	6.8	7.2	7.7
September	5.2	9.9	11.2	12.2	13.1	5.6	10.2	11.5	12.6	13.6
October	6.6	10.9	12.3	13.4	14.4	6.4	11.1	12.6	13.6	14.7
November	7.6	11.6	12.7	13.5	14.3	8.1	11.8	12.9	13.7	14.5
December	9.4	13.0	14.0	14.8	15.5	9.7	13.3	14.3	15.1	15.9
Annual	11.8	14.1	14.9	15.6	16.3	11.9	14.2	15.1	15.8	16.4

A significant wave height of 13.6 m was measured by a buoy located at the Mizzen L-11 field on 8 March 2003. This wave height is slightly greater than the 50-year annual significant wave height for both grid points.

The maximum individual wave heights and extreme associated peak periods are presented Tables 3.12 and 3.13, respectively. Maximum individual wave heights and the extreme associated peak periods peak during February for both points.

Table 3.12. Extreme maximum wave height estimates for return periods of 1, 10, 25, 50 and 100 years in Region 2.

	GridPoint #13428					GridPoint #14697				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	18.3	23.6	25.1	26.3	27.4	18.7	24.0	25.6	26.8	28.0
February	16.4	24.3	26.6	28.2	29.9	17.4	24.3	26.4	28.0	29.5
March	13.8	19.7	21.4	22.6	23.9	14.4	20.1	21.9	23.2	24.5
April	11.1	17.1	18.8	20.1	21.3	11.9	17.5	19.3	20.5	21.8
May	8.5	15.9	18.0	19.5	21.1	9.2	16.0	18.1	19.7	21.2
June	6.8	12.2	13.7	14.9	16.0	7.5	12.2	13.6	14.6	15.6
July	6.3	10.1	11.2	12.0	12.8	6.6	10.1	11.2	12.0	12.8
August	6.8	12.2	13.7	14.8	15.9	7.4	11.5	12.8	13.7	14.6
September	9.7	17.8	20.3	22.0	23.7	10.6	18.7	21.1	23.0	24.8
October	12.3	20.2	22.7	24.6	26.5	12.0	20.6	23.2	25.1	27.0
November	14.0	21.3	23.3	24.8	26.3	15.0	21.7	23.7	25.2	26.7
December	17.3	24.0	25.9	27.3	28.6	17.9	24.5	26.4	27.9	29.4
Annual	21.7	26.0	27.7	28.9	30.2	22.0	26.4	28.1	29.3	30.6

Table 3.13. Extreme Associated Peak Period Estimates for Return Periods of 1, 10, 25, 50 and 100 Years in Region 2.

	GridPoint #13428					GridPoint #14697				
Period	**1**	**10**	**25**	**50**	**100**	**1**	**10**	**25**	**50**	**100**
January	13.2	14.9	15.3	15.6	15.9	13.3	14.9	15.3	15.6	15.9
February	12.3	15.1	15.8	16.3	16.8	12.7	14.8	15.4	15.8	16.3
March	11.9	13.4	13.8	14.1	14.3	11.9	13.4	13.8	14.1	14.4
April	11.2	12.8	13.2	13.4	13.7	11.5	12.9	13.2	13.5	13.7
May	9.7	12.4	13.0	13.4	13.8	10.0	12.4	13.0	13.5	13.9
June	8.3	11.3	12.0	12.5	13.0	9.1	11.0	11.5	11.9	12.2
July	8.4	10.7	11.3	11.7	12.1	8.6	10.5	11.0	11.4	11.7
August	8.7	11.3	11.8	12.2	12.6	9.2	11.0	11.5	11.8	12.1
September	10.8	13.7	14.4	14.8	15.3	10.9	13.6	14.2	14.7	15.1
October	12.0	13.8	14.3	14.7	15.0	11.5	13.8	14.4	14.8	15.2
November	12.1	14.1	14.5	14.9	15.2	12.1	14.1	14.6	15.0	15.4
December	13.0	15.0	15.5	15.8	16.2	13.2	14.8	15.3	15.6	15.9
Annual	14.3	15.5	16.0	16.3	16.6	14.2	15.5	15.9	16.3	16.6

3.3. Physical Oceanography

Oceans (2011) provides a detailed review of currents in the Study Area. The Study Area was divided into three sub-areas (Orphan Basin, Flemish Pass/Sackville Spur, and NE Grand Banks) for analysis purposes. Current velocities and water mass properties (temperature and salinity) at various water depths are provided in Section 4 of Oceans (2011). A summary of the major currents in the Study Area is provided below.

3.3.1. Major Currents in the Study Area

The Study Area overlaps the southern part of Orphan Basin, the Sackville Spur, the Northeast Newfoundland Slope, northern Flemish Pass, and the Jeanne d'Arc Basin. The large scale circulation off the coast of Newfoundland and Labrador is dominated by well established currents that flow along the margins of the Continental Shelf. The two major current systems in the area are the Labrador Current and the North Atlantic Current (Colbourne and Foote 2000). The Labrador Current is the main current in the Study Area and it transports sub-polar water to lower latitudes along the Continental Shelf of eastern Canada. Oceanographic studies show that this strong western boundary current follows the shelf break with relatively low variability compared to the mean flow. Over the Grand Banks a weaker current system is observed where the variability often exceeds that of the mean flow (see Figure 4.1 in Oceans 2011).

The Labrador Current consists of two major branches. The inshore branch of the Labrador Current is ~ 100 km wide (Stein 2007) and is steered by the local underwater topography through the Avalon Channel. The stronger offshore branch flows along the shelf break over the upper portion of the Continental Slope. The offshore branch passes between the 400 m and 1200 m isobaths (Lazier and Wright 1993). This branch of the Labrador Current divides east of 48°W, resulting in part of the branch flowing to the east around Flemish Cap and the other flowing south around the eastern edge of the Grand Banks and through Flemish Pass. Within Flemish Pass, the width of the Labrador Current is reduced to 50 km with speeds of about 30 cm/s (Stein 2007). This flow transports cold, relatively low salinity Labrador Slope water into the region. To the southeast of the Flemish Cap the North Atlantic Current transports warmer, high salinity water to the northeast along the southeast slope of Grand Bank and the Flemish Cap (Figure 3.2).

The outer branch of the Labrador Current exhibits a distinct seasonal variation in flow speeds (Lazier and Wright 1993), in which mean flows are a maximum in October and a minimum in March and April. This annual cycle is reported to be the result of the large annual variation in the steric height over the continental shelf in relation to the much less variable internal density characteristic of the adjoining deep waters. The additional freshwater in spring and summer is largely confined to the waters over the shelf. In summer, the difference in sea level between the shelf and open ocean is 0.09 m greater than in winter (Lazier and Wright 1993). This difference produces a greater horizontal surface pressure gradient and hence, stronger mean flows.

3.4. Sea Ice and Icebergs

The analysis of sea ice and icebergs in the Study Area was divided into two regions: Jeanne d'Arc Basin (Region 1) and Orphan Basin/Flemish Pass (Region 2; see Figure 3.1). Table 5.1 in Oceans (2011) provides definitions of various ice types.

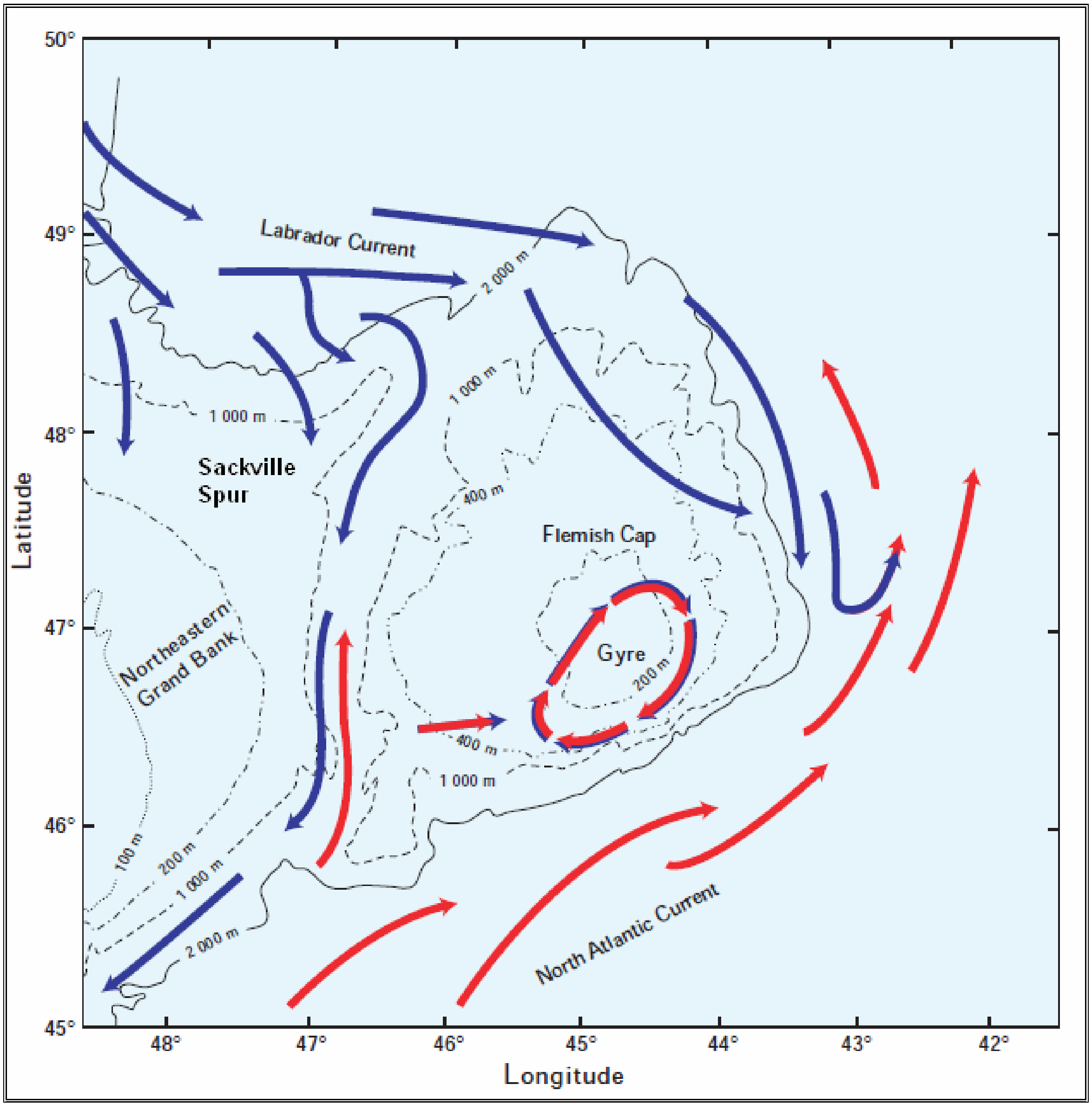


Figure 3.2. The major circulation features around the Flemish Cap and Sackville Spur (modified from Colbourne and Foote 2000).

3.4.1. Sea Ice

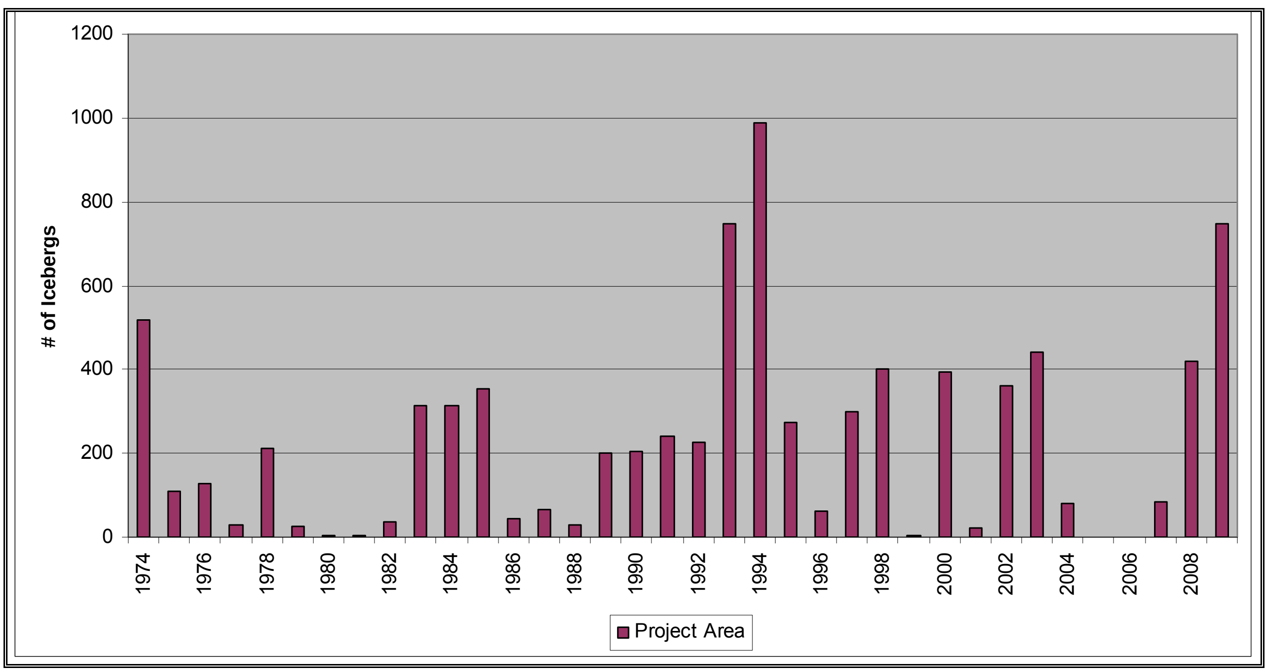
A weekly analysis of the Canadian Ice Service's 30-Year Frequency of Presence of Sea Ice in Region 1 shows that the area is affected by sea ice beginning the week of 8 January and lasting until the week beginning 28 May. First-year ice is the predominate ice type from 26 February until the week of 28 May. The 30-year median concentration of sea ice reaches its maximum extent within Region 1 during the week of 12 March (see Figure 5.2 in Oceans 2011). During this period, the northernmost part of Region 1 has 6/10ths coverage or less.

In Region 2, the area is affected by sea ice beginning the week of 15 January and lasting until the week beginning 7 May. The week of 19 February is the period when the presence of sea ice is the greatest over the area. During this period, most of Region 2 is covered by at least 1–15 % sea ice while ice is present in the southeast 34–50% of the time. The 30-year median concentration of sea ice reaches its maximum extent within the area the week of 12 March (see Figure 5.4 in Oceans 2011). During this period, Region 2 has 3/10ths coverage or less. Concentrations of sea ice are 1/10ths or less for the remainder of the year.

3.4.2. Icebergs

An analysis was performed to determine the threat posed by icebergs in the Project Area; more specifically in Regions 1 and 2 (see Figure 3.1). The International Ice Patrol Iceberg Sightings Database from 1974-2009 was used as the primary data source in this analysis.

In Region 1, the number of iceberg sightings ranged from one in some years to a maximum of 987 in 1994 (Figure 3.3). A monthly analysis (Table 3.14) shows that icebergs have been recorded within Region 1 from December to August; however, they are most prominent during April. With respect to size, the most prominent icebergs are small, accounting for 27.7% of observed icebergs within Region 1. Large icebergs occur 10.4% of the time in this Region.



Source: IIP.

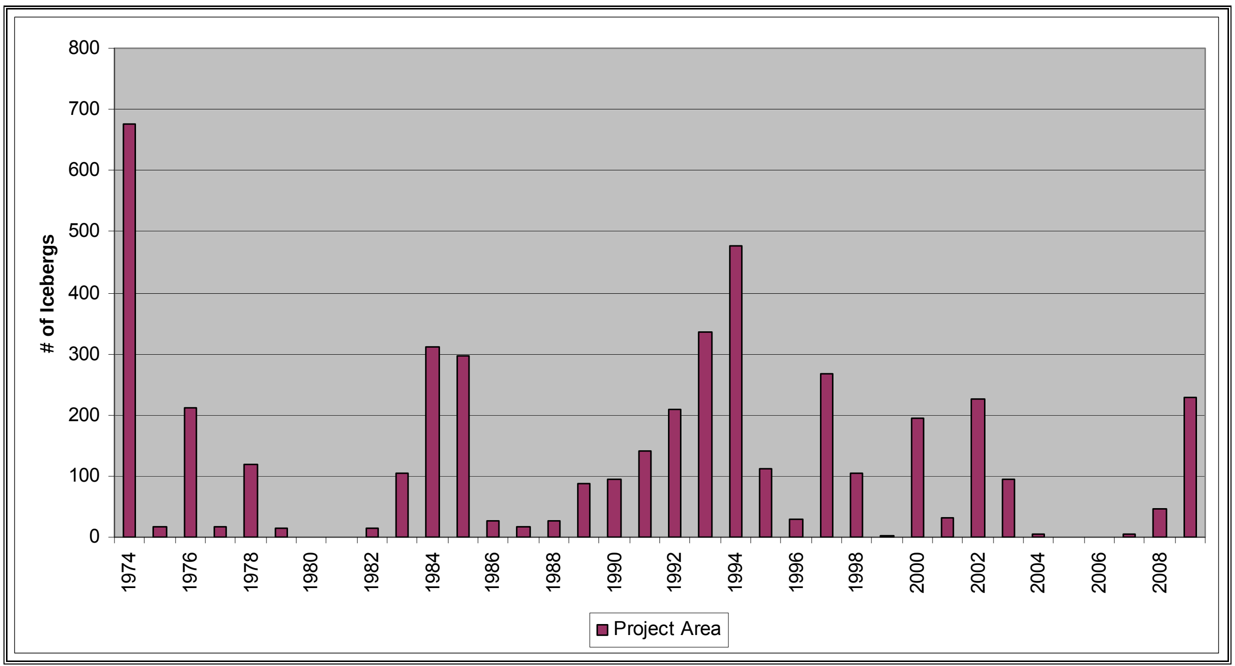
Figure 3.3. Iceberg sightings in Region 1 of the Project Area.

Table 3.14. Iceberg size (number of icebergs) by month in Region 1 of the Project Area.

Iceberg Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Total
General	12	72	302	607	832	288	55	2	0	0	0	0	2170
Unidentified Target	11	85	114	24	63	29	7	2	0	2	0	2	339
Growler	1	12	78	155	187	34	25	0	0	0	0	0	492
Bergy Bit	5	4	66	110	77	23	5	0	0	0	0	0	290
Small	27	242	721	933	684	139	48	1	0	0	0	0	2795
Medium	12	112	596	886	752	240	62	2	0	0	0	1	2663
Large	2	22	202	370	280	151	20	0	0	0	0	0	1047
Very Large	0	1	18	34	15	3	3	0	0	0	0	0	74
Randomized	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Monthly	70	552	2125	3171	2993	924	236	7	0	2	0	3	10083

Source: IIP.

In Region 2, the number of iceberg sightings ranged from none in some years to a maximum of 676 in 1974 (Figure 3.4). A monthly analysis (Table 3.15) shows that icebergs have been recorded within Region 2 from December to August; however, they are most prominent during March in this Region. With respect to size, the most prominent icebergs are medium-sized, accounting for 26.3% of observed icebergs within Region 2. Large icebergs occur 8.2% of the time in Region 2.



Source: IIP.

Figure 3.4. Iceberg sightings in Region 2 of the Project Area.

Table 3.15. Iceberg size (number of icebergs) by month in Region 2 of the Project Area.

Iceberg Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Total
General	0	10	176	185	271	100	57	1	0	0	0	0	800
Unidentified Target	25	30	39	14	53	26	6	0	0	1	0	1	195
Growler	0	5	38	21	40	2	3	0	0	2	0	0	111
Bergy Bit	3	5	16	17	19	2	0	0	0	0	0	0	62
Small	11	85	277	135	133	46	18	3	0	0	0	0	708
Medium	11	41	277	165	176	60	22	5	0	0	0	1	758
Large	1	4	73	44	65	40	7	2	0	0	0	0	236
Very Large	0	0	3	4	1	1	0	1	0	0	0	0	10
Randomized	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Monthly	51	180	899	585	758	277	113	12	0	3	0	2	2880

Source: IIP.

4.0 Biological and Socio-economic Environment

The biological and socio-economic environments in and near the Study Area have been described in the Orphan Basin SEA (LGL 2003) and more recently, exploration and drilling EAs and their amendments for Orphan Basin (LGL 2005, 2006a, 2009) and Jeanne d'Arc Basin (Christian 2008; LGL 2006b, 2007a,b, 2008a,b). In addition to updated information, summaries of relevant information from these documents are presented in the following sections for fish and fish habitat, seabirds, marine mammals, sea turtles and commercial fisheries, species at risk and potentially sensitive areas.

4.1. Ecosystem

An ecosystem is an inter-related complex of physical, chemical, geological, and biological components that can be defined at many different scales from a relatively small area (that may only contain one habitat type, e.g., a shelf) to a relatively large regional area ecosystem which is topographically and oceanographically complex with shelves, slopes, and valleys and several major water masses and currents (e.g., the NW Atlantic). This EA focuses on components of the ecosystem such as selected species and stages of fish, seabirds and marine mammals that are important economically and socially, with potential to interact with the Project. This is the valued ecosystem component (VEC) approach to EA which is detailed in Section 5.0. The VECs and/or their respective groups are discussed in the following sections.

4.2. Fish and Fish Habitat

This subsection provides a description of the existing fish and fish habitat in the Study Area. Fish habitat in the Study Area is considered first, followed by a discussion of fish (macroinvertebrates and fishes) in the area.

4.2.1. Fish Habitat

In this EA, fish habitat includes physical, chemical, and biological aspects of the marine environment used by macroinvertebrate and fish species in the Study Area. The physical and chemical nature of the bottom substrate is a critical factor affecting the characterization of associated marine biological communities. The biological component of fish habitat refers to phytoplankton, zooplankton, and benthos (i.e., infaunal and epibenthic invertebrates not typically harvested during commercial fisheries in the Study Area [e.g., polychaetes, echinoderms]).

4.2.2. Plankton

Plankton is composed of free-floating organisms that form the basis of the pelagic ecosystem. Members include bacteria, fungi, phytoplankton, and zooplankton (mostly invertebrates, but may also include eggs and larvae of fishes, known as ichthyoplankton). In simplest terms, phytoplankton (e.g., diatoms) produce carbon compounds through the utilization of sunlight, carbon dioxide, and nutrients (e.g., nitrogen, phosphorus, silicon); this process is called primary production. Herbaceous zooplankton (e.g., calanoid copepods, the dominant component of NW Atlantic zooplankton) feed on phytoplankton, a growth process known as secondary production. The herbivores in turn are ingested by predators (i.e., tertiary production) such as predacious zooplankton (e.g., chaetognaths, jellyfish, etc.), all of which may be grazed by higher predators such as fish, seabirds, and marine mammals. This food web also links to the benthic ecosystem through bacterial degradation processes, dissolved and particulate carbon, and direct predation. An understanding of plankton production is important because areas of enhanced production and (or) biomass are areas where fish, seabirds, and marine mammals congregate to feed (LGL 2003).

Phytoplankton distribution, productivity, and growth regulation in high-latitude ecosystems constitute a complex system with light, nutrients, and herbivore grazing being the principal factors limiting phytoplankton regulations (Harrison and Li 2008). In the northwest Atlantic, there is generally a spring plankton bloom (May/June) which is often followed by a smaller bloom in the fall (September/October). This general pattern likely applies to the Study Area. There may be areas of enhanced production in the Study Area, similar to other slope areas that have been studied. For example, MODIS chlorophyll 'a' concentration images for October 2009 to November 2011 (http://www2.mar.dfo-mpo.gc.ca/bin/cgi/ocean/seawifs_1.pl) indicate highest chlorophyll 'a' concentrations in the southwestern portion of the Study Area in April and November, and in the northeastern portion of the Study Area in April/May and October. Typically, the spring bloom of phytoplankton is the driving force of high-latitude marine ecosystem dynamics. Sunlight has been considered the limiting factor for development of the spring bloom, however, factors such as latitude and water column stratification are also important factors (Wu et al. 2008). Zooplankton reproduction is tied to the phytoplankton bloom, which either coincides with or immediately follows the brief but intense phytoplankton blooms in the high latitudes (Huntley et al. 1983; Head et al. 2000; Head and Pepin 2008). Zooplankton are the primary link between primary production and higher-level organisms in the marine ecosystem. They transfer organic carbon from phytoplankton to fish, marine mammals, and birds higher in the food chain. Zooplankton are a food source for a broad spectrum of species and they contribute faecal matter and dead zooplankton to the benthic communities. More information on phytoplankton within the Study Area is available in Subsection 3.2.1 of the Orphan Basin SEA (LGL 2003), and the Husky New Drill Centre Construction and Operations Program EA (Section 5.4 *in* LGL 2006b).

Planktonic organisms are so ubiquitous and abundant, and many have such rapid generation times that there will be essentially no effect on planktonic communities from the proposed seismic program. Planktonic stages of commercial invertebrates (e.g., shrimp, snow crab) and fishes (e.g., cod) are described in following subsections.

4.2.3. Benthos

Benthic invertebrates are bottom-dwelling organisms that can be classified into three categories: infaunal organisms, sessile organisms, and epibenthic species (Barrie et al. 1980). Infaunal organisms live on or are buried in soft substrates and include bivalves, polychaetes, amphipods, sipunculids, ophiuroids, and some gastropods. Sessile organisms live attached to hard substrates and would include barnacles, tunicates, bryzoans, holothurians, and some anemones. The epibenthic organisms are active swimmers that remain in close association to the seabed and include mysiids, amphipods, and decapods.

Benthic invertebrate communities can be spatially variable due to physical habitat characteristics such as water depth, substrate type, currents, and sedimentation. The primary factors affecting the structure and function of such communities in high latitude communities are water mass differences, sediment characteristics, and ice scour (Carey 1991). The wide range of these characteristics within the Study Area ensures a variety of benthic communities. The structure and metabolism of benthic communities can also be directly affected by the rate of sedimentation of organic detritus in shelf and deeper waters

(Desrosiers et al. 2000). The seasonality of phytoplankton can influence production in benthic communities, adding temporal variability to a highly heterogeneous community.

As indicated in the Orphan Basin SEA (LGL 2003) and the Husky New Drill Centre Construction and Operations Program EA (Section 5.4 *in* LGL 2006b). , there are large gaps in the current knowledge of benthic ecosystems of the offshore waters of Newfoundland and Labrador. The existing literature, although extensive in appearance, tends to be spatially restricted and often species specific. Subsection 3.2.2 of LGL (2003) and Subsection 5.5.1.1 of LGL (2006b) include more general information on benthos in the vicinity of the Study Area. Deepwater corals have gained more focus in recent years. Some information on corals occurring within the Study Area is presented in the following subsection.

4.2.4. Deep-water Corals

A variety of coral groups occur in Newfoundland and Labrador waters and include scleractinians (solitary stony corals), antipatharians (black wire corals), alcyonaceans (large and small gorgonians, soft corals), and pennatulaceans (sea pens) (Wareham and Edinger 2007; Wareham 2009). Corals are largely distributed along the edge of the continental shelf and slope off Newfoundland and Labrador (Edinger et al. 2007; Wareham and Edinger 2007). Typically, they are found in canyons and along the edges of channels (Breeze et al. 1997), deeper than 200 m. Soft corals are distributed in both shallow and deep waters, while horny and stony corals (hard corals) are typically restricted to deep water areas. Most grow on hard substrate (Gass 2003), such as large gorgonian corals (Breeze et al. 1997). Others, such as small gorgonians, cup corals, and sea pens, prefer sand or mud substrates (Edinger et al. 2007). In total, thirty species of corals were documented and comprised of two antipatharians (black wire corals), 13 alcyonaceans (large gorgonians, small gorgonians, and soft corals), four scleractinians (solitary stony corals), and 11 pennatulaceans (sea pens). The authors noted that corals were more widely distributed on the continental edge and slope.

A recently published DFO technical report (Gilkinson and Edinger 2009) presents knowledge on the ecology of deep-sea corals of Newfoundland and Labrador waters, including information on biogeography, life history, biochemistry, and relation to fishes. Wareham (2009) updated deep-sea coral distribution data for the Newfoundland and Labrador and Arctic Regions to partially fill information gaps previously identified by Wareham and Edinger (2007).

According to distribution maps provided by Wareham (2009), there are approximately 16 species of corals occurring within or adjacent to the southwestern part of the Study Area. The species identified include large gorgonians (*Keratoisis ornata*, *Paragorgia arborea*, and *Paramuricea* spp.), small gorgonians (*Acanthogorgia armata*, *Acanella arbuscula*, *Radicipes gracilis*), and soft corals (*Anthomastus grandiflorus*, *Duva florida*, and *Gersemia rubiformis*). One scleractinian species (*Flabellum alabastrum*) and six pennatulacean species (*Pennatula phosphorea*, *Pennatula grandis*, *Anthoptilum grandiflorum*, *Umbellula lindahli*, *Halipteris finmarchica*, and *Funiculinia quandrangularis*) are also noted to occur there. No antipatharian species were noted by Wareham (2009) to occur within this EA's Study Area. According to Kenchington et al. (2010), antipatharian species (i.e., black corals) also occur in the slope region in the southwestern part of the Study Area. A recent DFO Science Advisory Report (DFO 2010a) also discusses the occurrence and ecological function of corals in Canadian waters. The majority of coral species were observed to occur on the continental slope, with the exception of several soft corals (e.g., *Gersemia rubiformis*) found distributed on the shelf.

The patterns of association between deep-sea corals fish and invertebrate species, based on DFO scientific surveys and ROV surveys are discussed by Edinger et al. (2009). Although there were no dramatic relationships between corals and abundance of the ten groundfish species studied, there was a weak but statistically significant positive correlation between coral species richness and fish species richness, suggesting that habitats that support diverse corals may also support diverse assemblages of fishes. Although relationships between corals and groundfish or invertebrates are not obligate and may result from coincidence, conservation areas established for corals may effectively protect populations of groundfish, including some commercial species (Edinger et al. 2009). By increasing the spatial and hydrodynamic complexity of habitats, deep-sea corals may provide important, but probably not critical, habitat for a wide variety of fishes. Effects of deep-sea corals on fish habitat and communities may include higher prey abundance, greater water turbulence, and resting places for a wide variety of fish size classes (Auster et al. 2005, and Costello et al. 2005 *in* Edinger et al. 2009).

4.2.5. Fish

For the purposes of this EA, fish includes commercial fishery-targeted macroinvertebrate and fish species, incidental commercial fishery bycatch species, and macroinvertebrates and fishes caught during DFO Research Vessel (RV) surveys in the Study Area.

4.2.5.1. Macroinvertebrates and Fishes Primarily Targeted in Commercial Fisheries

Two macroinvertebrate species, northern shrimp (*Pandalus borealis*), and snow crab (*Chionoecetes opilio*), dominate the reported landings of commercial catches within the Study Area during 2003 to 2009 (combined catch weight >99% of total). Other macroinvertebrates that account for at least 0.1% of the 2003 to 2009 total catch weight include Stimpson's surf clam (*Mactromeris polynyma)* (0.4%) and Greenland cockle (*Serripes groenlandicus*) (0.1%). Greenland halibut (*Reinhardtius hippoglossoidess*) is the only fish species reported to account for at least 0.1% of total catch weight within Study Area from 2003 to 2009. These five species are profiled below.

Northern Shrimp

The primary cold-water shrimp resource in the N Atlantic, the northern shrimp is distributed from Davis Strait to the Gulf of Maine. It usually occupies soft muddy substrates up to depths of 600 m in temperatures of 1°C to 6°C (DFO 2008a). Larger individuals generally occur in deeper waters (DFO 2006a). A diel vertical migration is undertaken with shrimp moving off the bottom into the water column during the day to feed on small pelagic crustaceans. They migrate up the water column at night, feeding on pelagic copepods and krill (DFO 2006a). After insemination, female shrimp may migrate to shallower water areas where the water temperatures are most appropriate for embryonic development and subsequent larval hatch (http://www.dfo-mpo.gc.ca/science/publications/article/2009/08-31-09-eng.html). Northern shrimp are protandric hermaphrodites (Orr et al. 2009). They first mature as males, mate as males for one to several years, and then change to females for the remainder of their lives (DFO 2008a). Eggs are typically extruded in the summer and remain attached to the female until the following spring, when the female migrates to shallow coastal waters to spawn (Nicolajsen 1994 *in* Ollerhead et al. 2004). The hatched larvae float to the surface and commence feeding on planktonic organisms (DFO 2006a). Northern shrimp are known to live for more than eight years in some areas and are large enough for recruitment to the fishery by as early as three years of age (DFO 2008a).

As with most crustaceans, northern shrimp grow by moulting their shells. During this period, the new shell is soft, causing them to be highly vulnerable to predators such as Greenland halibut, Atlantic cod (DFO 2006a), Atlantic halibut, skates, wolffish and harp seals (*Pagophilus groenlandicus*) (DFO 2000).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate that most northern shrimp catches within the Study Area occurred on the northeastern Newfoundland Slope in areas with water depths ranging between 200 and 500 m. Scattered shrimp catches were also reported in the Jeanne d'Arc Basin and the Orphan Basin. No shrimp catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the Study Area in 2008 and 2009, most of the northern shrimp were caught at mean water depths ranging between 100 and 300 m during both spring and fall surveys.

Snow Crab

The snow crab, a decapod crustacean, occurs over a broad depth range in the NW Atlantic from Greenland south to the Gulf of Maine (DFO 2010b). Snow crab distribution is widespread and continuous in waters off Newfoundland and southern Labrador. Large males are most common on mud or mud/sand, while smaller crabs are common on harder substrates.

The snow crab life cycle features a 12 to 15 week planktonic larval period, following spring hatching, involving several stages before settlement. Benthic juveniles of both sexes molt frequently, and at about 40 mm CW (~ 4 years of age) they may become sexually mature. Female crabs carry the fertilized eggs for about two years (DFO 2010b).

Snow crab typically feed on fish, clams, benthic worms, brittle stars, shrimps and crustaceans, including smaller snow crabs. Their predators include various groundfish and seals (DFO 2010b).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate a wider distribution catch locations for snow crab than for northern shrimp. Most snow crab catches were made inside the 200 m isobath in the Jeanne d'Arc Basin located in the southwestern portion of the Study Area. Scattered harvest locations were reported for the shallower regions of the northeastern Newfoundland Slope and the western Flemish Pass Slope. No snow crab catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the study Area in 2008 and 2009, most of the snow crab was caught at mean water depths <200 m during the fall surveys.

Stimpson's Surf Clam

This bivalve mollusc is a circumboreal species, inhabiting both the Atlantic and Pacific Oceans. It is the largest clam in the Northwestern Atlantic Ocean and occurs from Labrador to Rhode Island, often on medium to coarse sand substrate (Abbott 1974 *in* Christian et al. 2010). In the Canadian part of its range, this species occurs in commercial quantities in the offshore areas of the Scotian Shelf and Eastern Grand Banks, and inshore areas off southwest Nova Scotia and in the Gulf of St. Lawrence (DFO 1989a, 1999, 2004a *in* Christian et al. 2010). The Stimpson's surfclam appears to prefer medium to coarse sand substrate in which they burrow (DFO 2009 *in* Christian et al. 2010).

Surf clam spawning in the offshore areas typically occurs during the fall (DFO 2009 *in* Christian et al. 2010). Davis and Shumway (1996 *in* Christian et al. 2010) report that larval hatch occurs within days of spawning and that larvae remain planktonic for 1 to 2 months before settlement to the bottom substrate. Stimpson's surf clams are filter feeders with a microalgal diet (e.g., dinoflagellates) (Smith and Wikfors 1992 *in* Christian et al. 2010). Predators of the surf clam include sea stars, whelk, crabs and large groundfish (Himmelman and Hamel 1993, Rochette et al.1995, Morissette and Himmelman 2000 *in* Christian et al. 2010).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate that most surf clam catches within the Study Area occurred at southwestern part of the Study Area at locations with water depths <100 m.

<u>Greenland Halibut</u>

The Greenland halibut is distributed throughout cold, deep waters of the Labrador-eastern Newfoundland area, inhabiting the continental shelf and slope at depths of 200 to 600 m or more. The majority of the adult population is distributed in the deep and warm N Atlantic waters (e.g., Davis Strait, between Greenland and Baffin Island) where spawning occurs in winter or early spring (Templeman 1973; Bowering 1983; Bowering and Brodie 1995). Larvae and juveniles are transported south by oceanic currents where they colonize the deep channels (Bowering 1983; Bowering and Brodie 1995). Greenland halibut typically move progressively offshore to the deep edges of the continental slope with increasing age and size (Bowering and Brodie 1995). With increasing maturity most Greenland halibut presumably migrate northward to areas such as Davis Strait to spawn (Templeman 1973; Chumakov 1975; Bowering and Brodie 1995). Small scale localized spawning may also occur along the deep slopes of the continental shelf throughout its range (Bowering and Brodie 1995).

In addition to shrimp, Greenland halibut feed on a variety of species, including small pelagic crustaceans, small fish (e.g., Arctic cod, capelin), larger fish (e.g., redfish, grenadier), and squid (DFO 2008b).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate few catch locations for Greenland halibut within the Study Area. The area with the highest concentration of Greenland halibut catch locations is on the northeastern Newfoundland Slope where water depths range between 500 and 1500 m. No Greenland halibut catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the Study Area in 2008 and 2009, most of the Greenland halibut were caught at mean water depths >300 m during both spring and fall surveys.

<u>Greenland Cockle</u>

This cockle species is widely distributed throughout the Arctic Ocean and southward in varying degrees (Golikov and Scarlato 1973 *in* Christian et al. 2010). In the Northwest Atlantic Ocean, this bivalve is found from Greenland to Cape Cod at subtidal depths > 9 m. Barrie (1979 *in* Christian et al. 2010) found this cockle species on sandy substrates within a depth range of 6 to 18 m at various Labrador locations. It is approximately 100 mm in diameter at full growth (Gosner 1979 *in* Christian et al. 2010). The life history of the Greenland Cockle is poorly understood.

This cockle displays intense escape behaviour towards the sea stars *Leptasterias polaris* and *Asterias rubens,* two of its primary predators (Legault and Himmelman 1993 *in* Christian et al. 2010). Other predators of the Greenland cockle include demersal fish (e.g., cod, haddock) (Dolgov and Yaragina 1990 *in* Christian et al. 2010) and marine mammals (Fisher and Stewart 1997, Born et al. 2003 *in* Christian et al. 2010).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate that most cockle catches within the Study Area occurred at southwestern part of the Study Area at locations with water depths <100 m.

4.2.5.2. Other Fishes Caught in the Commercial Fishery

Other species that have been caught during commercial fisheries being prosecuted within the Study Area during recent years include the following:

- Yellowtail flounder (*Limanda ferruginea*);
- Skate (*Raja* spp.);
- Roughhead grenadier (*Macrourus berglax*);
- Capelin (*Mallotus villosus*);
- Atlantic halibut (*Hippoglossus hippoglossus*);
- American plaice (*Hippoglossoides platessoides*);
- Redfish (*Sebastes* spp.);
- Swordfish (*Xiphias gladius*);
- Tunas (*Thunnus* spp.);
- Atlantic cod (*Gadus morhua*); and
- Wolffishes (*Anarhichas* spp.).

More fishery-related details for these species are included in Subsection 4.3 of this EA. All of these species are briefly profiled in this subsection, except for the wolffishes, which are profiled in Section 4.6 on Species at Risk.

Yellowtail Flounder

Yellowtail flounder inhabit the continental shelf of the NW Atlantic from Labrador to Chesapeake Bay at depths ranging from 10 to 100 m. It has reached its northern limit of commercial concentrations on the Grand Bank off the east coast of Newfoundland. Yellowtail spawning on the Grand Bank generally occurs between May and September with peaks during the latter part of June. It tends to occur at depths less than 100 m and at water temperatures exceeding 2ºC (LGL 2006b). The eggs, larvae and early juvenile stages of yellowtail are pelagic. Because of its small mouth size, this flounder is restricted in its choice of prey. The most common prey of yellowtail flounder includes polychaetes, amphipods, shrimp cumaceans, isopods and small fish (LGL 2006b).

Juvenile and adult yellowtail are generally concentrated on the southern Grand Bank, on or near the Southeast Shoal where the substrate consists primarily of sand (Unit Area 3Nc, primarily) (Walsh et al. 2001 *in* LGL 2006b). Walsh et al. (2006 *in* LGL 2006b) discussed the distribution and abundance of yellowtail flounder on the Grand Bank based on spring and fall trawl surveys. They indicated the greatest concentrations of yellowtail flounder southwest of the Study Area in the vicinity of the Southeast Shoal.

Scattered commercial fishery catches of yellowtail flounder were reported in the western and southwestern portions of the Study Area (i.e., Jeanne d'Arc Basin) during the April to October period, 2003-2009, at locations with water depths <100 m. No yellowtail flounder catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the study Area in 2008 and 2009, most of the yellowtail flounder catch weight was taken at mean water depths <100 m during both spring and fall surveys.

Skate

Commercial catches of skates consist of several skate species; however, thorny skate (*Amblyraja radiata*) dominates the catch composition. In Canadian commercial catches, about 95% of the skate catch are thorny skates (Kulka and Miri 2007, Kulka and Mowbray 1999 *in* Simpson and Miri 2010). Thus, the skate fishery on the Grand Banks can be considered a directed fishery for thorny skate.

Thorny skate is a widely distributed species in temperate and arctic waters of the North Atlantic. In the western Atlantic, these skate are distributed from Greenland to South Carolina, with the center of distribution on the Grand Banks in NAFO Divisions 3LNO (Simpson and Miri 2010). Thorny skate occur on both hard and soft substrates (Kulka et al. 1996 *in* JW 2007) but are primarily associated with muddy, sandy and pebble substrates typical of Grand Banks sediment (Kulka and Miri 2003a *in* JW 2007).

The migration patterns of the thorny skate are not fully understood, but evidence suggests a seasonal migration between the continental shelf edge during December to June, and the top of the banks during the remainder of the year (Kulka and Mowbray 1998 *in* JW 2007). All available evidence suggests that thorny skates in Div. 3LNOPs comprise a single population (Kulka and Miri 2007). Males mature at smaller sizes than females with size at maturity increasing from north to south. Ovaries of sexually mature females hold 10 to 12 pairs of eggs in various developmental stages (Kulka and Miri 2003a *in* JW 2007). Thorny skate deposit 6 to 40 egg cases per year (DFO 2003b *in* JW 2007). Larger thorny skate produce larger egg cases, but it is not known if egg case size is related to survival rates (Kulka and Miri 2003a *in* JW 2007).

Thorny skate feed on a variety of invertebrates and fish including polychaetes, crabs and whelks (Kulka and Miri 2003a *in* JW 2007). The diets of larger skates include fish prey such as sculpins, redfish, sand launce and small haddock. Significant amounts of fish offal have been found in skate stomach and this coupled with the ventral mouth location suggests that thorny skate are opportunistic bottom feeders.

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate few catch locations for thorny skate within the Study Area. Reported catch locations are primarily distributed in the southwestern portion of the Study Area where water depths range from <100 in Jeanne d'Arc Basin to >1000 m on the northeastern Newfoundland Shelf and southern Flemish Pass. No thorny skate catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the study Area in 2008 and 2009, most of the thorny skate catch were caught at mean water depths ranging from 100 to 500 m during both spring and fall surveys.

Roughhead Grenadier

The roughhead grenadier occurs in deep water along coasts in subarctic to temperate waters on both sides of the N Atlantic. In the NW Atlantic, this species of grenadier occurs from Davis Strait along the continental slope, off Newfoundland, off Nova Scotia on Banquereau, Sable Island and Browns Bank, and on Georges Bank (Scott and Scott 1988). The roughhead grenadier is predominant at depths ranging from 800 to 1,500 m, although they may inhabit depths between 200 and 2,000 m (Murua and De Cardenas 2005 *in* González-Costas and Murua 2007). Catches tend to be highest at water temperatures ranging between 2.0 and 3.5ºC (Scott and Scott 1988). The roughhead grenadier is an abundant and widespread species in the NW Atlantic. This fish generally occurs both on the shelf and on the continental slope at depths ranging from 400 to 1,200 m. It has been found at depths as shallow as 200 m and as deep as 2,700 m.

Spawning is thought to occur during the winter and early spring. Little is known about the spawning grounds of this fish off Newfoundland although some believe that some spawning does occur on the southern and southeastern slopes of the Grand Banks (Scott and Scott 1988; COSEWIC 2007). Food on the roughhead grenadier consists of a variety of benthic invertebrates including bivalve molluscs, shrimp, seastars, polychaetes and some fish. These grenadier have been found in the stomachs of Atlantic cod. This grenadier species is quickly becoming an important commercial fish in the NW Atlantic. Presently its fishery is unregulated since it is usually taken as bycatch in the Greenland halibut fishery. During April to October between 2003 and 2009, commercial fishery roughhead grenadier catches were reported in the southern Flemish Pass and on the northeast Newfoundland Slope at locations with depths of about 1000 m.

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate few catch locations for roughhead grenadier within the Study Area. The area with the highest concentration of Greenland halibut catch locations is on the northeastern Newfoundland Slope where water depths range between 500 and 1500 m. A few catches were also reported in the southern Flemish Pass. No roughhead grenadier catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the study Area in 2008 and 2009, most of the roughhead grenadier were caught at mean water depths >400 m during the fall surveys.

Roughhead grenadier is currently designated as special concern under COSEWIC.

Capelin

Capelin is a small pelagic species that has a circumpolar distribution in the northern hemisphere (DFO 2006b). Capelin are often found along the coasts during the spawning season and occur predominately in offshore waters (e.g., Grand Banks) while immature and maturing. Migration towards the coast precedes spawning on beaches or in deeper waters (Nakashima and Wheeler 2002; DFO 2006b). The preferred spawning substrate is usually fine to coarse gravels. On beaches, capelin usually spawn at 5 to 8.5°C, but have been observed to spawn at 4 to 10°C. Beach spawning is more prevalent at night. On the bottom, spawning temperatures can be as low as 2°C as observed on the Southeast Shoal, located far south of the Study Area. Capelin are able to spawn at the age of two and males and most females usually die following spawning. Spawning commences in early June and may continue through July or August depending upon tides, winds and water temperatures (Scott and Scott 1988; Nakashima and Wheeler 2002). Incubation varies with ambient temperature and lasts approximately 15 days at 10°C (Scott and Scott 1988). Once hatched, larval capelin can be found at the surface to depths >40 m (Frank et al. 1993).

Capelin prey consists of planktonic organisms comprised of primarily of euphausiids and copepods. Capelin feeding is seasonal with intense feeding late winter and early spring leading up to the spawning cycle when feed ceases. Feeding recommences several weeks after cessation of spawning (Scott and Scott 1988).

Capelin is a major component in marine ecosystem dynamics as they facilitate the transfer of energy between trophic levels, principally between primary and secondary producers to higher trophic levels (DFO 2006b). Capelin predators comprise most major fish species including Atlantic cod, haddock, herring, flatfish species, dogfish and others. Several marine mammal species including minke whales, fin whales, harp and ringed seals as well as a variety of seabirds also prey on capelin.

Other than the fishery, the primary cause of capelin mortality is predation and as such variations in capelin abundances are directly linked to natural causes (DFO 2006b). Capelin have a short life span (usually five years or less), abundances are linked to a few age classes. Management of capelin fisheries tends to be conservative as a result of the prominent role of capelin in the marine ecosystem.

Commercial fishery capelin catches during the April to October period, 2003-2009, were reported in the central portion of the Study Area on the northeastern Newfoundland Slope, primarily at locations with water depths ranging from 200 to 400 m. Based on DFO RV survey data collected in the study Area in 2008 and 2009, most of the capelin catch was at mean water depths <300 m during the spring surveys.

Atlantic Halibut

Atlantic halibut, the largest of the flatfishes, is typically found along the slopes of the continental shelf. Atlantic halibut move seasonally between deep and shallow waters, apparently avoiding temperatures below 2.5ºC (Scott and Scott 1988). The spawning grounds of the Atlantic halibut are not clearly defined. The fertilized eggs are slightly positively buoyant so that they naturally disperse and only gradually float toward the ocean's surface. Once hatched, the developing larvae live off their yolk for the next six to eight weeks while their digestive system develops so they can begin feeding on natural zooplankton. After a few weeks of feeding, they metamorphose from a bilaterally symmetrical larva to an asymmetrical flatfish, and are ready to assume a bottom-living habit. At this point they are approximately 20-mm long. As juveniles, Atlantic halibut feed mainly on invertebrates, including annelid worms, crabs, shrimps, and euphausiids. Young adults (between 30 to 80-cm in length) consume both invertebrates and fish, while mature adults (greater than 80-cm) feed entirely on fishes (Scott and Scott 1988).

A few commercial catches of Atlantic halibut were reported in the southern Flemish Pass and on the northeast Newfoundland Slope during the April to October period, 2003-2009, at locations with depths of about 1000 m.

American Plaice

American plaice is a bottom-dwelling flatfish that resides on both sides of the Atlantic (DFO 2006c; COSEWIC 2009). American plaice that reside in the W Atlantic region range from the deep waters off Baffin Island and western Hudson's Bay southward to the Gulf of Maine and Rhode Island (Scott and Scott 1988). In Newfoundland waters, plaice occurs both inshore and offshore over a wide variety of bottom types (Morgan 2000). It is tolerant of a wide range of salinities and has been observed in estuaries (Scott and Scott 1988; Jury et al. 1994). Plaice are typically found at depths of approximately 90 to 250 m, but have been found as deep as 1,383 m. Most commercially harvested plaice are taken at depths of 125 to 200 m. Commercial fishery catches of American plaice between April and October during 2003 to 2009 were reported in the southwestern portion of the Study Area. Catches were sporadically scattered throughout the <200 m Jeanne d'Arc Basin area, and more densely distributed out to about a 400 m depth on the northeast Newfoundland Slope. It is a coldwater species, preferring water temperatures of 0°C to 1.5°C (Scott and Scott 1988). Tagging studies in Newfoundland waters suggest

that, once settled, juveniles and adults are rather sedentary and do not undertake large scale migrations (DFO 2008c). However, older plaice have been known to move up to 160 km (Powles 1965). Migrations have been observed in Canadian waters to deeper offshore waters in the winter, returning to shallower water in the spring (Hebert and Wearing-Wilde 2002 *in* Johnson 2004).

In Newfoundland waters, American plaice spawn during the spring (Scott and Scott 1988). Within the Study Area, there are limited data with respect to the actual spawning times. American plaice in the Newfoundland Region have no specific spawning areas; rather spawning occurs over the entire area occupied (DFO 2008c) with the most intense spawning coincident with areas where the higher abundance of adults are found (Busby et al. 2007). Large quantities of eggs are released and fertilized over a period of days on the seabed (Johnson 2004). Eggs are buoyant and drift into the upper water column, where they are widely dispersed, allowing for some intermingling of stocks. Intermingling of adults is minimal. Hatching time is temperature dependant, occurring in 11 to 14 days at temperatures of 5°C (Scott and Scott 1988). Larvae are 4 to 6 mm in length when they hatch and begin to settle to the seabed when they reach 18 to 34 mm in length and their body flattens (Fahay 1983).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate a concentration of American plaice catch locations on the northeastern Newfoundland Slope where water depths range between 200 and 500 m. Reported American plaice catches were also scattered across Jeanne d'Arc Basin at depths <200 m. No American plaice catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the study Area in 2008 and 2009, American plaice were caught throughout a wide range of mean water depths (from <100 m to >800 m) during both spring and fall surveys.

The Newfoundland and Labrador population of American plaice is currently designated as threatened under COSEWIC.

<u>Redfish</u>

The NW Atlantic redfish consists of a complex of three species identified as Acadian redfish (*S. fasciatus*), golden redfish (*S. marinus*), and deepwater redfish (*S. mentella*) (DFO 2008d). The deepwater redfish is the dominant species in northern areas, including the Study Area. The redfish distribution in the NW Atlantic ranges from the Gulf of Maine, northwards off Nova Scotia and southern Newfoundland banks, in the Gulf of St. Lawrence, and along the continental slope and deep channels from the southwestern Grand Bank to areas as far north as Baffin Island. Redfish are also present in the area of Flemish Cap and west of Greenland.

These species inhabit cool waters (3 to 8°C) along the slopes of banks and deep channels in depths of 100 to 700 m (Scott and Scott 1988; DFO 2008d). Commercial fishery catches of redfish between April and October during 2003 to 2009 were reported within the Study Area out to about a 500 m depth on the northeast Newfoundland Slope. Redfish are generally slow growing and long lived fishes (DFO 2008d).

The reproductive cycle of redfish differs from that of other fish species. Unlike many other species, fertilization in redfish is internal and females bear live young. Mating takes place in the fall most likely between September and December and females carry the developing embryos until they are extruded as free swimming larvae in spring. Larval extrusion takes place from April to July depending on the areas and species. Mating and larval extrusion do not necessarily occur in the same locations.

Generally found near the bottom, redfish have been observed to undertake diel vertical migrations, moving off the bottom at night to follow the migration of their prey (DFO 2008d). Redfish are pelagic or bathypelagic feeders, feeding primarily on zooplankton such as copepods, amphipods and euphausiids. Fishes and crustaceans become more important in the diet of larger redfish (Scott and Scott 1988).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate a concentration of redfish catch locations on the northeastern Newfoundland Slope where water depths range between 200 and 500 m. No redfish catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the study Area in 2008 and 2009, most of the redfish caught were deepwater redfish. The highest catches of deepwater redfish occurred at mean water depths ranging from 200 to 600 m during both spring and fall surveys.

Deepwater redfish and the Atlantic population of Acadian redfish are currently designated as threatened under COSEWIC.

Swordfish and Tunas

The pelagicspecies group comprised of swordfish and other tunas (apart from bluefin tuna) have unique biological properties that influence the fisheries and their management. They are highly migratory and transboundary in their distribution, and accordingly their management occurs with the regional fisheries management organization known as ICCAT. As a group, their distribution and fisheries tend to be profoundly influenced by environmental conditions, notably water temperature. Hence, their occurrence in Canadian waters is often seasonal, and closely related to cycles in water temperature. As a species group, individuals tend to be large, and can often exceed 100 kg. Within a species such as bigeye tuna, larger individuals tend to be found in the relatively cool Canadian waters, since larger individuals are usually more cold-tolerant. While in Canadian waters, individuals of this species group feed heavily but there are no records of reproduction (DFO 2006d).

Commercial fishery catches of swordfish and tunas during the April to October period, 2003 to 2009, were reported in the southern Flemish Pass at the southern boundary of the Study Area in an area with water depths >1000 m.

Atlantic Cod

The Atlantic cod is a demersal fish that inhabits cold (10 to 15°C) and very cold (less than 0 to 5°C) waters in coastal areas and in offshore waters overlying the continental shelf throughout the NW and NE Atlantic Ocean (COSEWIC 2003c). The species is found contiguously along the east coast of Canada from Baffin Island to Georges Bank. Outside Canadian waters in the NW Atlantic, cod can be found on the northeast and southeast tips of Grand Bank and on Flemish Cap. During the first few weeks of life, cod eggs and larvae are found in the upper 50 m of the water column. As juveniles, cod are settled on the bottom and tend to occur in nearshore habitats with vertical structure such as eelgrass (*Zostera marina*) and macroalgae. As adults, the habitat requirements of cod are increasingly diverse.

Atlantic cod typically spawn over a period of less than three months in water that may vary in depth from tens to hundreds of metres (COSEWIC 2003c). Cod are described as batch spawners because only a small percentage (5 to 25%) of the female's egg total is released at any given time during a three to six week period. After hatching, larvae obtain nourishment from a yolk sac until they have reached a length of 1.5 to 2.0 mm. During the larval stage, the young feed on phytoplankton and small zooplankton in the

upper 10 to 50 m of the water column. After the larval stage, the juveniles settle to the bottom where they appear to remain for a period of 1 to 4 years. These settlement areas are known to range from very shallow (<10 to 30 m) coastal waters to moderately deep (50 to 150 m) waters on offshore banks. After this settlement period, it is believed that the fish begin to undertake seasonal movements and migrations characteristic of adults.

Dispersal in Atlantic cod appears to be limited to the egg and larval phases of life, during which surface and near-surface water currents and turbulence are the primary determinants of horizontal and vertical displacement in the water column (COSEWIC 2003c). For some cod populations, eggs and larvae are capable of dispersing very long distances. For example, cod eggs spawned off southeastern Labrador (NAFO Division 2J) may possibly disperse as far south as Grand Bank. By contrast, eggs spawned by cod in inshore, coastal waters, especially at the heads of large bays, may experience dispersal distances of a few kilometres or less.

Long-term movements by cod take the form of seasonal migrations (COSEWIC 2003c). These migrations can be attributed to geographical and seasonal differences in water temperature, food supply, and possibly spawning grounds. At one extreme, some inshore populations are suspected to have extremely short migrations, possibly limited to tens of kilometres, or less, in distance. By contrast, cod in other populations are known to traverse hundreds of kilometres during their seasonal migrations.

Two stocks of Atlantic cod occur within the Study Area; 2J3KL cod that occur off Labrador and eastern Newfoundland, and 3M cod that occur in the vicinity of the Flemish cap and Flemish Pass. Recent DFO fall sampling of the 2J3KL stock indicates that length-at-age and weight-at-age have improved since the low values of the early 1990s, particularly in NAFO Divisions 3K and 3L (DFO 2010c). The condition of cod in 3K and 3L has also improved from that seen in the early 1980s, although it did decline in 2009 from 2008 (DFO 2010c). The NAFO Division 3M cod stock was on fishing moratorium from 1999 to 2009. Recent assessment results indicate a substantial increase in Spawning Stock Biomass, which should continue only if current post-moratorium fishing level is maintained (Gonzàlez-Troncoso and Vázquez 2010).

Georeferenced commercial catch location data for the April to October period, 2003-2009, indicate few catch locations for Atlantic cod within the Study Area. Most were caught on the northeastern Newfoundland Slope at locations with water depths ranging from >200 to 1000 m. A few catches were also reported at the southwestern extreme of the Study Area in water depths <100 m. No Atlantic cod catches were reported within the seismic area proposed for 2011. Based on DFO RV survey data collected in the study Area in 2008 and 2009, most of the Atlantic cod were caught at mean water depths ranging from 200 to 300 m, primarily during the fall surveys.

Atlantic cod as a species is currently designated as special concern under Schedule 3 of the *SARA*. The Newfoundland and Labrador population of Atlantic cod is currently designated as endangered under COSEWIC.

Wolffishes

All three species of wolffish (i.e., northern, spotted and Atlantic) are discussed in Section 4.6 on Species at Risk. Both the northern and spotted wolffishes are currently designated as threatened under Schedule 1 of *SARA* and COSEWIC. The Atlantic wolffish is currently designated as special concern under Schedule 1 of *SARA* and COSEWIC.

4.2.6. Macroinvertebrates and Fishes Collected during DFO RV Surveys

Data collected during 2008 and 2009 spring and fall DFO RV surveys in the Study Area were analyzed, and catch weights and catch numbers of species/groups with combined annual catch weights of at least 100 kg are presented in Table 4.1.

Sponges accounted for 21.4% of the total 2008-2009 catch weight, followed by deepwater redfish (16.9%), northern shrimp (15.6%), capelin (6.9%), sand lance (5.3%), thorny skate (5.1%), American plaice (3.8%), roughhead grenadier (3.0%), yellowtail flounder (2.6%), Greenland halibut (2.3%), sea anemones (1.8%), Atlantic cod (1.7%), and snow crab (1.3%). All remaining species/groups in Table 4.1 represent <1% of the RV survey total catch weight. The distribution of geo-referenced catch locations reported during the 2008 and 2009 DFO RV surveys within the Study Area are shown in Figure 4.1.

The total catch weight of the 2008 and 2009 DFO RV surveys in the Study Area is divided into spring (March, May, June) and fall (October, November, December). Spring surveys accounted for 39.0% of the total catch weight, and fall surveys accounted for 61.0%. The average mean depths of catch during spring and fall surveys in 2008 and 2009 were 249 m (minimum = 20 m; maximum = 684 m) and 392 m (minimum = 57 m; maximum = 1,385 m), respectively.

The top five species/groups in terms of catch weight during the spring surveys were northern shrimp, deepwater redfish, capelin, sand lance and thorny skate. The top five species/groups in terms of catch weight during the fall surveys were sponges, deepwater redfish, northern shrimp, thorny skate and roughhead grenadier.

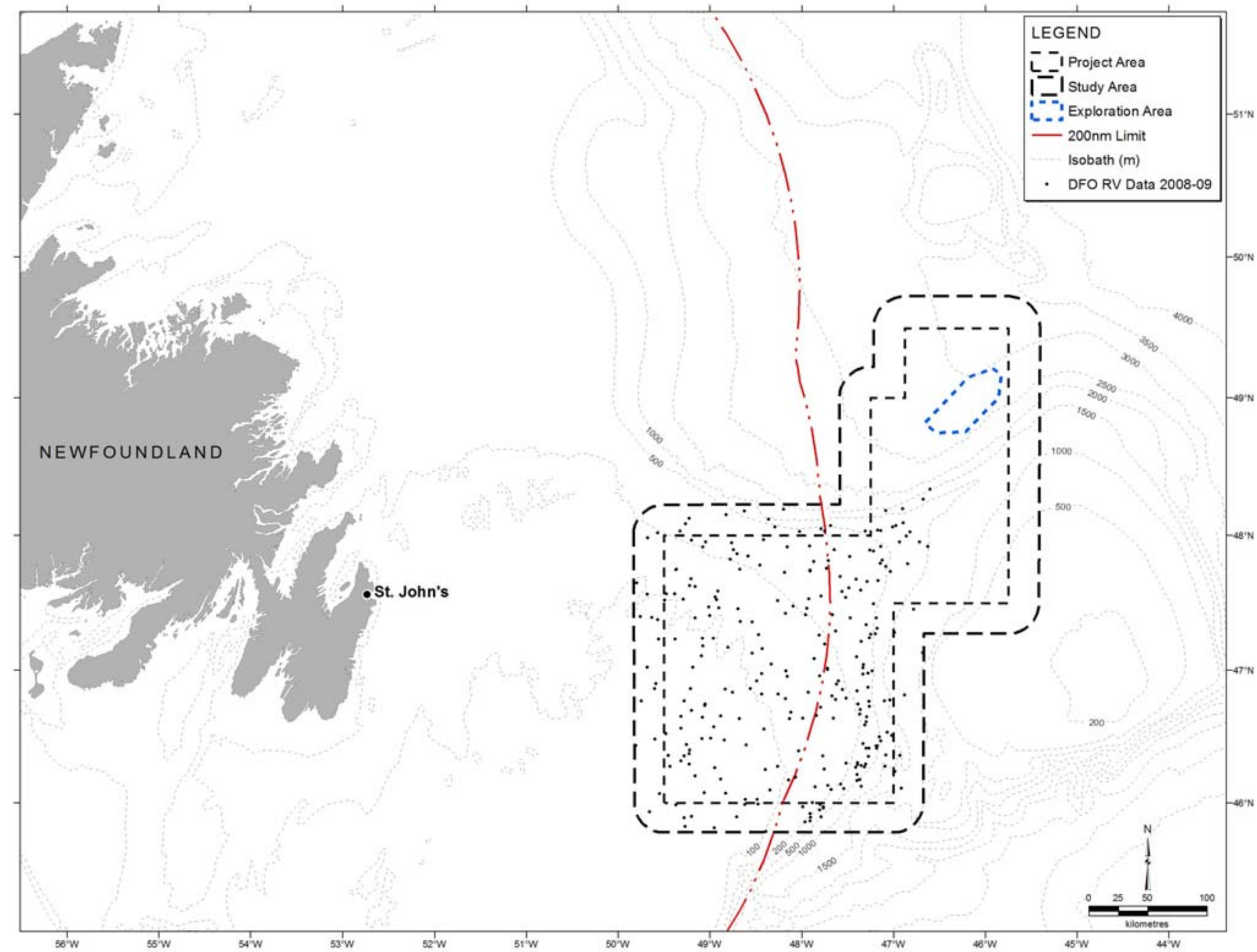
Species/groups that were caught predominantly during the spring RV surveys included capelin, sand lance, certain shrimp species, and sand dollars. Species/groups that were caught predominantly during the fall RV surveys included sponges, roughhead grenadier, sea anemones, Atlantic cod, blue hake, Vahl's eelpout, longnose eel, sea stars, marlin spike, roundnose grenadier, brittlestars, moustache sculpin, black dogfish, basketstars, and lanternfishes. Obviously, the survey depth differences between spring and fall surveys account for some of the seasonal differences (Table 4.2).

DFO RV survey catch weights in the study Area during 2008 and 2009 were analyzed for 11 mean catch depth ranges and results are presented in Table 4.3.

Table 4.1. Catch weights and numbers of macroinvertebrate and fish species collected during 2008 and 2009 DFO RV surveys within the Study Area.

Species	Catch Weight (kg)	Catch Number
Sponges	13,469	n/a
Deepwater redfish	10,589	54,940
Northern shrimp	9,769	1,888,945
Capelin	4,334	264,098
Sand lance (*Ammodytes dubius*)	3,360	295,720
Thorny skate	3,186	1,750
American plaice	2,379	11,451
Roughhead grenadier	1,901	4,661
Yellowtail flounder (*Limanda ferruginea*)	1,637	4,940
Greenland halibut	1,424	3,429
Sea anemones	1,153	1,720
Atlantic cod	1,095	1,835
Snow crab	807	4,215
Sea urchin (*Echinoidea*)	592	25,188
Shrimp (Natantia)	580	n/a
Blue hake (*Antimora rostrata*)	436	3,348
Jellyfishes (Scyphozoa)	323	n/a
Atlantic wolffish	316	549
Vahl's eelpout (*Lycodes vahlii*)	278	2,444
Sand dollars (Echinodermata)	231	8,097
Longnose eel (*Synaphobranchus kaupi*)	227	2,205
Shrimp (*Sergestes arcticus*)	216	202,456
Seastars (Various)	216	3,405
Marlin spike (*Nezumia bairdi*)	208	2,510
Spotted wolffish	203	78
Northern wolffish	173	45
Roundnose grenadier	169	1,553
Comb jellies (Ctenophora)	160	n/a
Brittlestars (Echinodermata)	150	569
Moustache sculpin (*Triglops* sp.)	146	11,692
Mailed sculpin (*Triglops murrayi*)	133	11,271
Black dogfish (*Centroscyllium fabricii*)	132	103
Basketstars (*Gorgonocephalidae*)	131	49
Witch flounder (*Glyptocephalus cynoglossus*)	128	437
Arctic eelpout (*Lycodes reticulatus*)	127	638
Lanternfishes (Myctophidae)	112	16,410
Longfin hake (*Urophycis chesteri*)	106	924

Source: DFO RV Survey Data 2008-2009. n/a denotes data unavailable.



Source: DFO RV Survey Data, 2008-2009.

Figure 4.1. DFO RV survey catch locations within the Study Area, 2008 and 2009 combined.

Table 4.2. Percentage catch and mean catch depth by survey season for macroinvertebrates and fishes caught during DFO RV surveys within the Study Area, 2008 and 2009 combined.

Species	Percentage Catch in Spring Surveys (%)	Spring Survey Mean Catch Depth (m)	Percentage Catch in Fall Survey (%)	Fall Survey Mean Catch Depth (m)
Sponges	1	324	99	496
Deepwater redfish	43	370	57	388
Northern shrimp	50	229-290	50	182-354
Capelin	98	166	2	206
Sand lance (*Ammodytes dubius*)	70	101	30	89
Thorny skate (*Raja radiata*)	47	285	53	281
American plaice	46	202	54	250
Roughhead grenadier	23	470	77	629
Yellowtail flounder	66	72	34	66
Greenland halibut	50	358	50	478
Sea anemones	22	323	78	388
Atlantic cod	18	221	82	222
Snow crab	35	162-175	65	183-187
Sea urchin (*Echinoidea*)	35	97-360	65	111-410
Shrimp (Natantia)	100	217	-	-
Blue hake (*Antimora rostrata*)	5	613	95	859
Jellyfishes	30	493	70	705
Atlantic wolffish	44	284	56	269
Vahl's eelpout (*Lycodes vahlii*)	22	381	78	338
Sand dollars	90	166-205	10	191-222
Longnose eel (*Synaphobranchus kaupi*)	7	583	93	787
Shrimp (*Sergestes arcticus*)	99	525	1	885
Sea stars	17	15-257	83	120-1,063
Marlin spike (*Nezumia bairdi*)	27	488	73	664
Spotted wolffish	54	312	46	242
Northern wolffish	45	544	55	649
Roundnose grenadier	7	629	93	922
Comb jellies	55	76	45	66
Brittlestars (Echinodermata)	27	204	73	275
Moustache sculpin (*Triglops* sp.)	2	179	98	147
Mailed sculpin (*Triglops murrayi*)	69	149	31	161
Black dogfish (*Centroscyllium fabricii*)	-	-	100	1,009
Basketstars (*Gorgonocephalidae*)	<1	229	>99	358
Witch flounder (*Glyptocephalus cynoglossus*)	47	371	53	497
Arctic eelpout (*Lycodes reticulatus*)	43	187	57	162
Lanternfishes (*Myctophidae*)	8	483	92	709
Longfin hake (*Urophycis chesteri*)	46	454	54	555

Source: DFO RV Survey Data 2008-2009.

Table 4.3. Total catch weights and predominant species caught at various mean catch depth ranges, 2008 and 2009 DFO RV surveys combined.

Mean Catch Depth Range	Total Catch Weight (kg)	Predominant Species
<100 m	7,214	Sand lance (30%) Yellowtail flounder (23%) Capelin (22%) American plaice (6%) Snow crab (3%)
≥100 m to <200 m	7,919	Northern shrimp (40%) Sand lance (12%) Capelin (9%) American plaice (7%) Snow crab (7%) Thorny skate (4%)
≥200 m to < 300 m	13,385	Northern shrimp (43%) Capelin (15%) Deepwater redfish (12%) Atlantic cod (7%) Thorny skate (5%) American plaice (3%) Shrimp (Natantia) (3%)
≥300 m to < 400 m	9,288	Deepwater redfish (53%) Thorny skate (18%) Northern shrimp (8%) American plaice (4%) Sea anemones (3%)
≥400 m to < 500 m	3,891	Deepwater redfish (56%) Sea anemones (9%) Thorny skate (7%) American plaice (4%) Roughhead grenadier (4%) Shrimp (*Sergestes arcticus*) (4%)
≥500 m to < 600 m	1,443	Deepwater redfish (50%) Roughhead grenadier (10%) American plaice (6%) Greenland halibut (5%) Sponges (4%) Sea anemones (3%)
≥600 m to < 700 m	3,631	Deepwater redfish (32%) Roughhead grenadier (17%) Sea anemones (11%) American plaice (9%) Greenland halibut (8%)
≥700 m to < 800 m	192	Roughhead grenadier (64%) Sponges (12%) Blue hake (9%)
≥800 m to < 900 m	2,377	Sponges (84%) Roughhead grenadier (4%) Greenland halibut (3%) Blue hake (2%) American plaice (2%)
≥900 m to < 1,000 m	297	Roughhead grenadier (30%) Blue hake (15%) Black dogfish (14%) Greenland halibut (11%) Longnose eel (5%)
≥1,000 m	12,866	Sponges (86%) Roughhead grenadier (3%) Blue hake (2%) Roundnose grenadier (1%) Jellyfish (1%)

Source: DFO RV Survey Data 2008-2009.

4.2.7. Macroinvertebrate and Fish Reproduction in the Study Area

Temporal and spatial details of macroinvertebrate and fish reproduction within the Study Area are provided in Table 4.4.

Table 4.4. Reproduction specifics of macroinvertebrate and fish species likely to reproduce within or near the Study Area.

Species	Locations of Reproductive Events	Times of Reproductive Events	Duration of Planktonic Stages
Northern shrimp	On banks and in channels over the extent of its distribution	Spawning in late summer/fall Fertilized eggs carried by female for 8 to 10 months and larvae hatch in the spring	12 to 16 weeks
Snow crab	On banks and possibly along some upper slope regions over the extent of its distribution	Mating in early spring Fertilized eggs carried by female for 2 years and larvae hatch in late spring/early summer	12 to 15 weeks
Stimpson's surf clam	Eastern Grand Banks	Fall	4 to 8 weeks
Greenland halibut	Spawning grounds extend from Davis Strait (south of 67°N) to south of Flemish Pass between 800 m and 2,000 m depth	Winter months	Uncertain
Greenland cockle	Eastern Grand Banks	Uncertain	Uncertain
Yellowtail flounder	Shallower sandy areas – typically <100 m water depth – at bottom	May to September, typically peaking in June/July Both eggs and larvae are planktonic.	Pelagic larvae are brief residents in the plankton
Thorny skate	Throughout distribution range	Year-round Eggs deposited in capsule (one egg per capsule), possibly on bottom	None
Roundnose grenadier	Uncertain	Uncertain	Uncertain
Roughhead grenadier	Uncertain	Winter/early spring	Uncertain
Capelin	Spawning generally on beaches or in deeper waters	Late June to early July	Several weeks
Atlantic halibut	Uncertain	Likely spawns between January and May. Both eggs and larvae are planktonic	6 to 8 weeks
American plaice	Spawning generally occurs throughout the range the population inhabits.	April to May	12 to 16 weeks
Redfish	Primarily along edge of shelf and banks, in slope waters, and in deep channels	Mating in late winter and release of young between April and July (peak in April)	No planktonic stage
Atlantic cod	Spawn along outer slopes of the shelf in depths from tens to hundred of metres	March to June	10 to 12 weeks
Wolffishes	Likely along the slope regions	September to November	Uncertain
Cusk	Uncertain	May to August	Presumed to be 4 to 16 weeks
Porbeagle shark	Very little known about the location of the pupping grounds	Mating in late summer and pupping during the winter	Uncertain

4.3. Commercial Fisheries

This section describes the existing commercial fisheries in the Study Area for Statoil's potential seismic and geohazard surveys and provides additional context for the area's foreign commercial fisheries. It also describes economic and logistical aspects of the fisheries.

Section 4.2 of this assessment describes the biological characteristics and status of the main commercial and other marine species, including prey for commercial species.

4.3.1. Data and Information Sources

The majority of the data used to characterize the fisheries in this section are quantities of harvest rather than harvest values since quantities are directly comparable from year to year, while values (for the same quantity of harvest) may vary annually with negotiated prices, changes in exchange rates and fluctuating market conditions. Although some species vary greatly in landed value (e.g. snow crab vs. turbot), in terms of potential interaction with the fisheries the level of fishing effort and gear utilized (better represented by quantities of harvest) is the better indicator.

4.3.1.1. Data and Other Sources of Information

Datasets

Fisheries within the Study Area are primarily managed by DFO and the North Atlantic Fisheries Organization (NAFO), for convention countries, while the domestic commercial fisheries analysis in this section is based primarily on data derived from the DFO Newfoundland and Labrador Region catch and effort datasets, foreign catches landed outside the regions are not included in these., To characterize area foreign fisheries, NAFO datasets are used, which capture both domestic and foreign fisher beyond the 200 NMi Exclusive Economic Zone (EEZ).

The NAFO data are derived from the STATLANT 21A dataset for 2003 to 2007. These data are not georeferenced and are only resolved geographically at the NAFO Division level. Thus the following analysis quantifies harvesting at for NAFO Division 3K, 3L and 3M (see Figure 4.2)[3] for NAFO managed stocks/species in these areas. Note that the STATLANT and DFO datasets are not mutually exclusive for Canadian catches.

The DFO data used in the report (DFO 1990 to 2009) represent all catch landed within Newfoundland and Labrador region (whether managed by NAFO or DFO, as described above).[4] The DFO catch data within the Study Area are georeferenced (typically >95% of the harvest, by quantity), so that past harvesting locations can be plotted with a high level of accuracy, and these locations are shown on the fisheries maps in this section. The positions given in the datasets are those recorded in the vessel's fishing log, and are reported in the database by degree and minute of latitude and longitude; thus the positions should be accurate within approximately 0.5 nautical mile of the reported co-ordinates. For some gear, such as mobile gear towed over an extensive area, or for extended gear, such as longlines,

[3] For an indication of location of effort by Convention nations see maps in NAFO Ad Hoc Working Group report, 2009 at http://archive.nafo.int/open/fc/2009/fcdoc09-02.pdf .)
[4] Most of the later data years are considered "preliminary", with the greatest potential for change being in value.

the reference point does not represent the full distribution of the gear or activity on the water. However, over many data entries, the reported locations create a fairly accurate indication of where such fishing activities occur. In addition, to provide a historical summary of catches in the general area of the proposed Project Area, DFO data for Unit Areas NAFO 3Le, 3Li, 3Lt, 3Lh, 3Lr, 3Ma and 3Kk are used (the Project Area UAs) for the 20-year period 1990 to 2009.

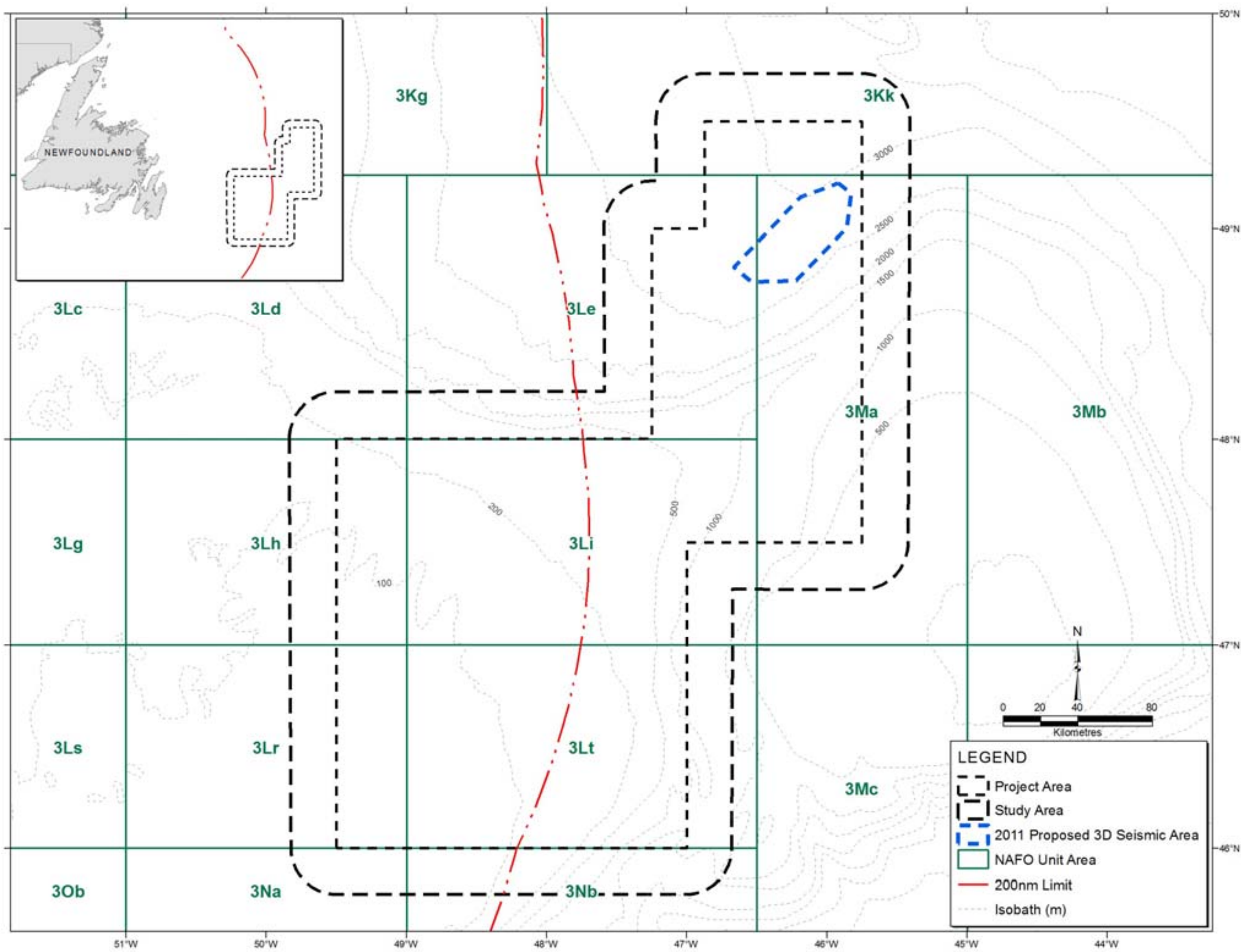


Figure 4.2. Study Area location relative to NAFO Unit Areas.

Consultations

The fisheries consultations and contacts for this assessment included representatives of Fisheries and Oceans Canada (DFO), One Ocean, the Fish, Food and Allied Workers Union (FFAW), the Association of Seafood Producers (ASP), Ocean Choice International (OCI), the Groundfish Enterprise Allocation Council (GEAC; Ottawa), Clearwater Seafoods (in Nova Scotia) and Icewater Seafoods. The consultations were undertaken to inform stakeholders about the proposed Statoil surveys, to gather information about fishing activities, and to determine any issues or concerns. Those consulted are listed in Appendix B. Fisheries-related information provided is reported under the discussions of the commercial fisheries below. Further information about the 2011 offshore fisheries obtained from industry stakeholders, as well as any issues and concerns raised by industry representatives, are discussed in Section 5.2.2.

Other Sources

Other sources consulted for this section include fisheries management plans, quota reports and other DFO documents, such as Science Advisory and Stock Status reports. These are listed in Section 6.0.

4.3.2. Regional NAFO Fisheries

The majority of the Study Area is outside Canada's 200-NMi EEZ, overlapping portions of NAFO UAs of 3K, 3L and 3M (see Figure 4.2). Several key fisheries beyond or overlapping the EEZ are managed by NAFO (e.g. northern shrimp); however, sedentary species (e.g. snow crab) are managed by DFO. Most fishing for relevant species in the NAFO Convention Regulatory Area (RA) is conducted using mobile bottom-tending trawls.

Table 4.5 presents average annual catches (2003 to 2007) of NAFO managed species for each Division which overlaps part of the Study Area. It indicates the catch of these species separately for Canadian vessels and other Convention nations, the total, and the percent the Canadian portion represents of the total, by managed species. Within these three Divisions collectively, the largest NAFO-managed catches during this period were northern shrimp, redfish, squid and Greenland halibut. The quantity and proportion of the foreign harvest of these species increases significantly moving north to south / southeast, with virtually no foreign harvest in 3K, 56% in 3L and nearly 100% in 3M.

Table 4.5. Average annual catches (Tonnes), 2003-2007 for NAFO convention managed species, by NAFO Division.

Species	Canadian (Tonnes)	Foreign (Tonnes)	Total (Tonnes)	Cdn % of Total
NAFO 3K				
Redfish (sp)	112.2	9.8	122.0	92.0
Squid (sp)	1,021.8	0.0	1,021.8	100
Total	1,134.0	9.8	1,143.8	99.1
NAFO 3L				
Atlantic Cod	926.8	13.0	939.8	98.6
Greenland Halibut / Turbot	1,120.0	9,205.6	10,325.6	10.8
American Plaice	55.4	278.0	333.4	16.6
Redfish (sp)	3.8	303.6	307.4	1.2
Shrimp (sp)	13,556.8	3,176.4	16,733.2	81.0
Squid (sp)	1,211.4	0.4	1,211.8	100
Witch Flounder	15.8	174.6	190.4	8.3
Yellowtail Flounder	163.0	17.8	180.8	90.2
Total	17,053.0	13,169.4	30,222.4	56.4
NAFO 3M				
Atlantic Cod	0.6	62.0	62.6	1.0
Greenland Halibut / Turbot	0.0	2,173.4	2,173.4	0.0
American Plaice	0.0	96.6	96.6	0.0
Redfish (sp)	0.0	4,687.2	4,687.2	0.0
Shrimp (sp)	2.0	33,815.4	33,817.4	0.0
Squid (sp)	0.0	5.4	5.4	0.0
Total	2.6	40,840.0	40,842.6	0.0

In these areas, the northern shrimp fishery is managed by NAFO in 3L and 3M. Division 3L has a 2011 Total Allowable Catch (TAC) for shrimp of 19,200 t (down from 30,000 t in 2010) of which Canada is allocated just over 83%, and it is planned to lower this again in 2012 to 17,000 t. The 3M shrimp fishery is managed through effort allocation (limiting the number of fishing days). Of the total fishing days (5,277) allowed in 2010, Canada had 4.3% (228 days) distributed amongst 16 vessels. However, for 2011, owing to concerns about the poor status of the shrimp resources, no 3M shrimp fishing will be permitted. NAFO notes that "When the scientific advice estimates that the stock shows signs of recovery, the fishery shall be re-opened in accordance with the effort allocation key in place for this fishery at the time of the closure".[5]

NAFO manages collectively the three redfish species found in the northwest Atlantic (*Sebastes fasciatus,* Acadian redfish, *S. mentella,* deepwater redfish, and *S. marinus,* golden redfish) in Divisions 3KLMNO, 1F and in Subarea 2. Recently (2010), the fishery in 3LN was re-opened after having been under moratorium. There is a TAC for each Division or Subarea, ranging between 6,000 t and 20,000 t in 2011; Canada is entitled to 42.6% of the TAC overall.

Squid has a 2011 quota of 34,000 t, which will remain until at least 2013, managed over Subareas 3 and 4. Greenland halibut / turbot, which is managed by NAFO in the 3L and 3M portions of the Study Area (but not 3K), has a 2011 quota of 12,734 t for all of 3LMNO; of this 1,910 t is allocated for Canada. NAFO management of this species has established a "progressive strategy" allowing for the annual adjustment of the TAC based on various indicators.

Although Canada typically has only a small percentage of the NAFO Atlantic cod TAC in Division 3M (0.8% or 80 t for 2011), Ocean Choice International (OCI) has stated that it has a 200 tonne allocation of 3M cod that it plans to fish in 2011 (D. Fudge, pers. comm., March 2011). The TAC for all the NAFO-managed species (including the Canadian and foreign allocations) can be found at http://www.nafo.int/fisheries/regulations/tac-quota.html.

In 2011, several other NAFO managed species in Convention areas were under moratorium. Relevant to the Study Area, there were bans on fishing cod in 3L, American plaice in 3L and 3M, and witch flounder in 3L.

4.3.3. Study Area Domestic Fisheries

4.3.3.1. 1990 to 2009 Catch Trends

The Canadian fisheries in the eastern Grand Banks area were dominated until the early 1990s by groundfish harvesting using stern otter trawls, primarily harvesting Atlantic cod, American plaice and a few other species. In 1992, with the acknowledgement of the collapse of several groundfish stocks, a harvesting moratorium was declared and directed fisheries for cod virtually vanished in this area. Since the collapse of these fisheries, formerly underutilized species – mainly northern shrimp and snow crab – have come to replace groundfish as the principal harvest on and in the waters east of the eastern Grand Banks, as they have in many other areas. Figures 4.3 to 4.5 summarize catch data for the seven fisheries UAs that the Project Area overlaps (Project Area UAs) and show the quantity of the total annual harvest in that area over the last twenty years, the total groundfish harvest, and the snow

[5] See http://www.nafo.int/fisheries/regulations/tac-quota.html; http://www.dfo-mpo.gc.ca/media/back-fiche/2010/hq-ac46a-eng.htm; pers. com. Ricardo Federizon, NAFO, February 2011.

crab and northern shrimp harvest for the same period. Although UA 3Ma was the source of much of the harvest in the early 1990s, over the past several years nearly 75% of the Study Area catch has come from 3Le (61%) and 3Lt (13.5%).

Today, in this area, snow crab harvesting (fixed gear) tends to be focused in areas along the shelf break and slope. Northern shrimp trawling (mobile gear) overlaps some of these areas, but these two gears have a potential to conflict with each other, and thus crab and shrimp do not typically overlap in time or location (as demonstrated clearly in Figures 4.9 to 4.16, below). Shrimp harvesting tends to extend into deeper water in the Study Area and farther eastward into the international waters, where it is also fished by several nations besides Canada within the general area of the Project Study Area (discussed above).

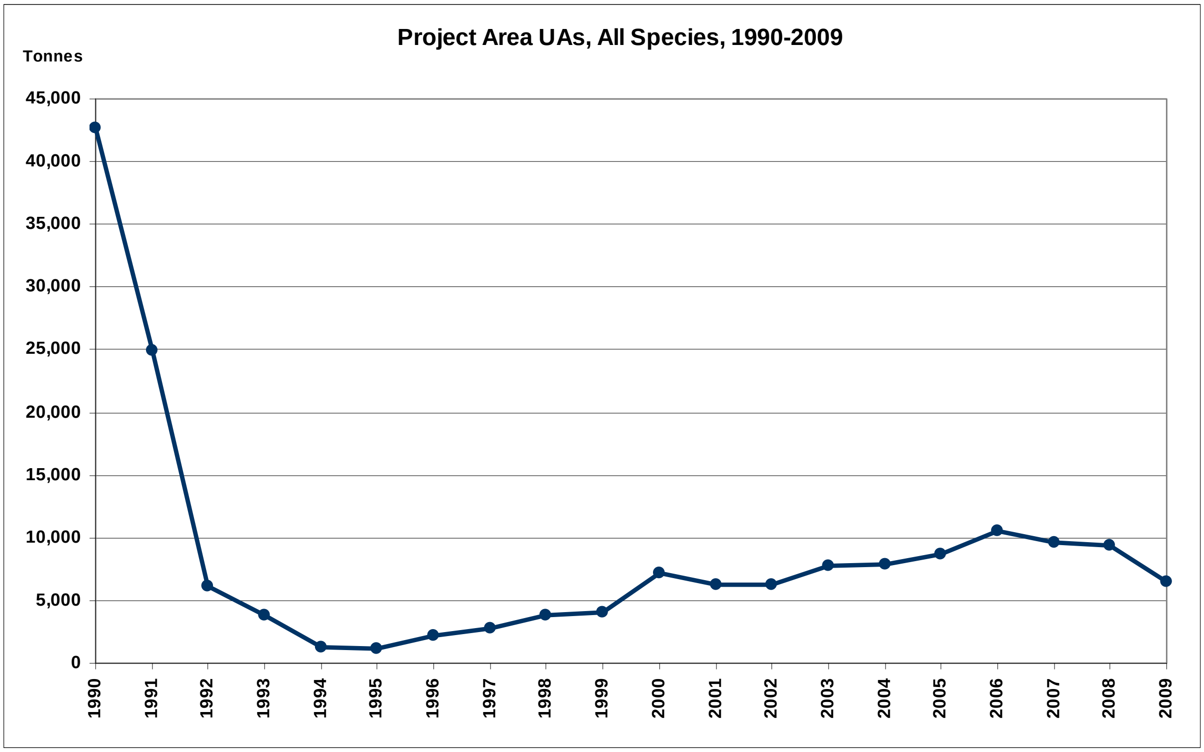


Figure 4.3. Harvest of all species from 1990 to 2009 within Project Area UAs.

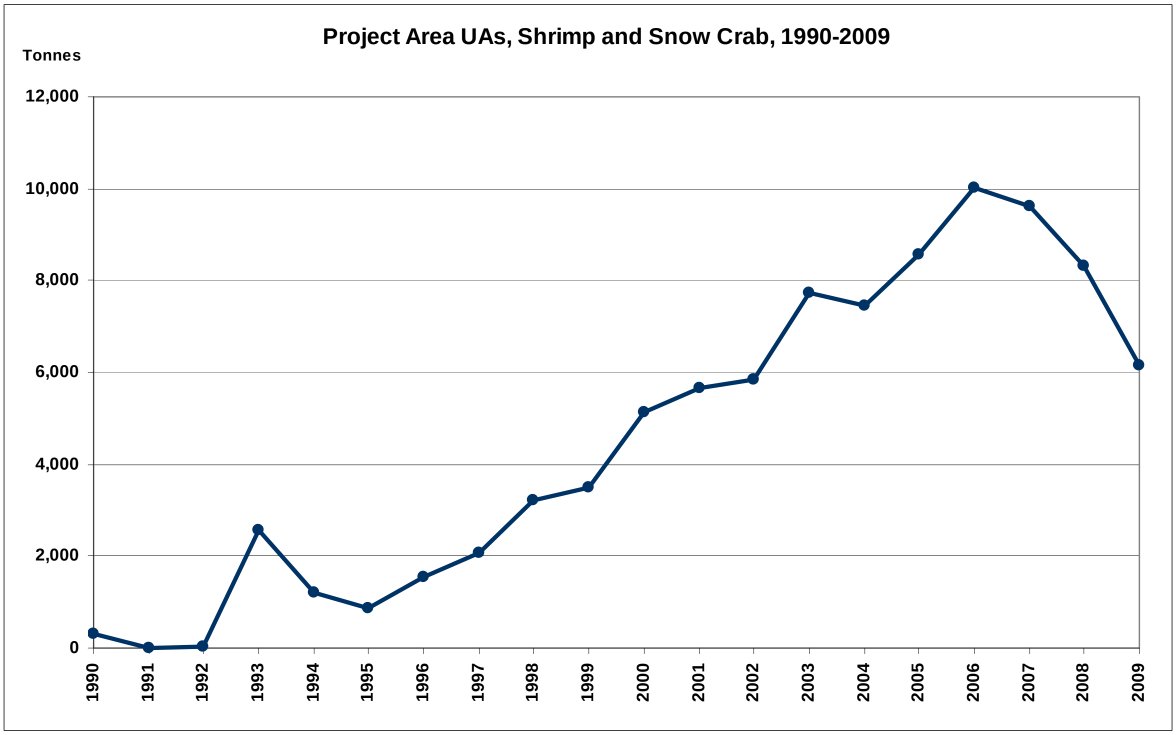


Figure 4.4. Shrimp and snow crab harvest from 1990 to 2009 within the Project Area UAs.

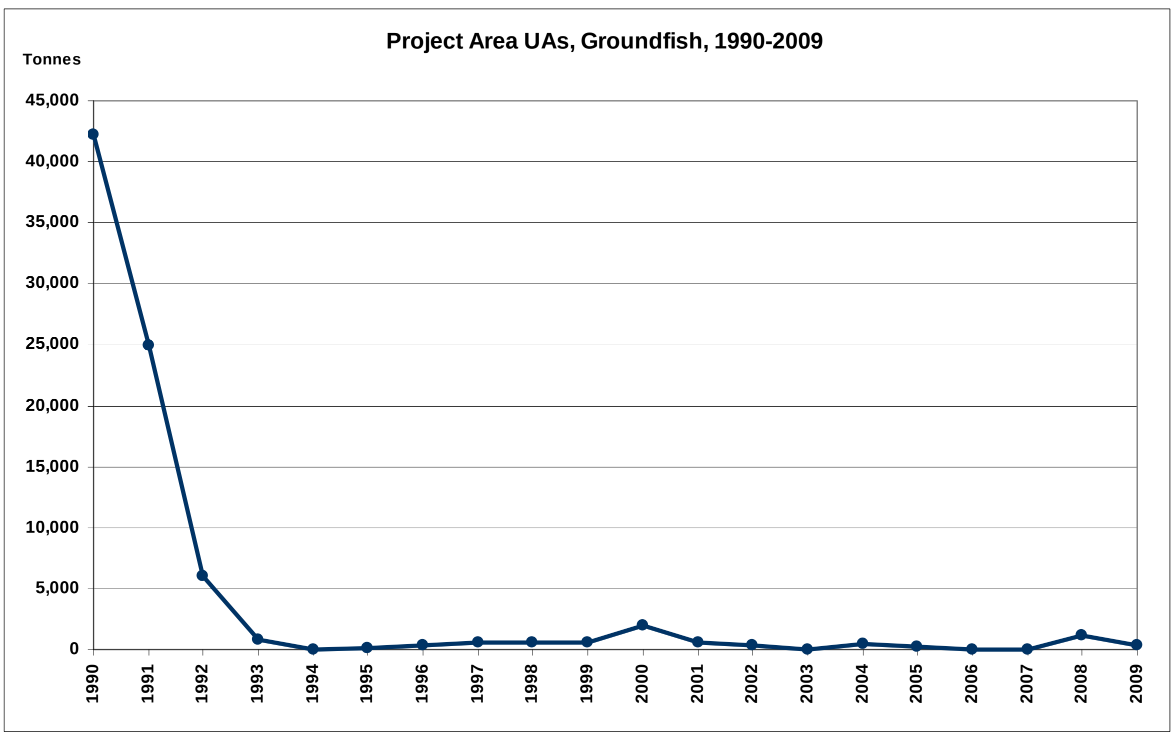


Figure 4.5. Groundfish harvest from 1990 to 2009 within the Project Area UAs.

4.3.3.2. 2003 to 2009, April to October Study Area Catch Analysis

Table 4.6 shows the average annual Canadian-landed harvest by species, 2003 to 2009, from within the Study Area from April to October period, based on the georeferenced DFO datasets. As the data show, the domestic harvest in the Study Area has been equally dominated by shrimp and crab throughout this period, in terms of quantity, though snow crab is a much higher value species.

Table 4.6. Average Study Area harvest by species, April to October, 2003-2009.

Species	Quantity (Tonnes)	% of Total	Value ($)	% of Total
Halibut	0.3	0.0	2,204	0.0
American Plaice	0.7	0.0	467	0.0
Yellowtail Flounder	4.4	0.0	3,000	0.0
Turbot/Greenland Halibut	20.7	0.1	34,323	0.1
Grenadier	2.9	0.0	1,004	0.0
Other Groundfish	1.0	0.0	243	0.0
Capelin	2.5	0.0	380	0.0
Clams, Surf	0.5	0.0	493	0.0
Cockles	1.9	0.0	1,600	0.0
Northern Shrimp	7,432.3	49.6	7,517,083	24.4
Snow Crab	7,504.4	50.1	23,293,001	75.5
Totals	14,971.4	100	30,853,797	100

The following graph indicates the changes in the total catch recorded annually within the Study Area for the 2003 to 2009 period. As the graph in Figure 4.6 indicates, the total quantity of the harvest increased fairly consistently after 2003, mainly the result of increasing shrimp catches in the Study Area, with a slight decline after 2006. However, significant reductions in shrimp quotas after 2010 are expected to result in a reversal of this general trend (as discussed above and below).

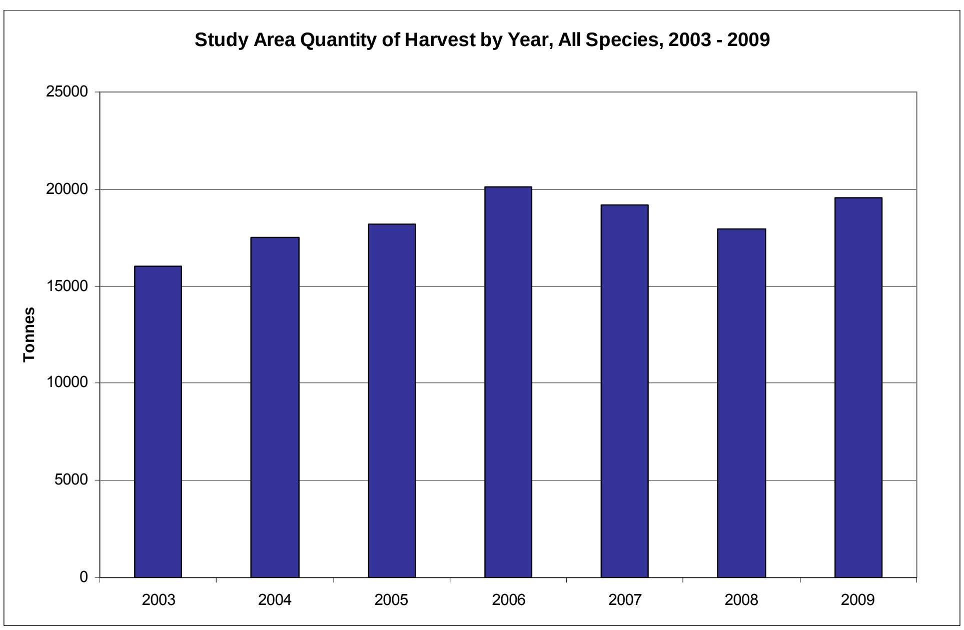


Figure 4.6. Harvest of all species within the Study Area, 2003 to 2009.

4.3.3.3. Harvesting Locations

The following map shows DFO dataset georeferenced fishing locations in relation to the Study Area for the period April to October, for 2003 to 2009, aggregated. Figures in following sections map the monthly variation in harvest for principal species and aggregated harvesting locations for these species from 2003 to 2009. As Figure 4.7 illustrates, most of the domestic fish harvesting in the general area is concentrated between the 100 m and 1000 m contours of the eastern Grand Bank, inside and - to a lesser extent - outside the 200-NMi EEZ, in particular in the central and western parts of the Study Area. The harvesting locations tend to be quite consistent from year to year, and this has been the case for most of the last decade.

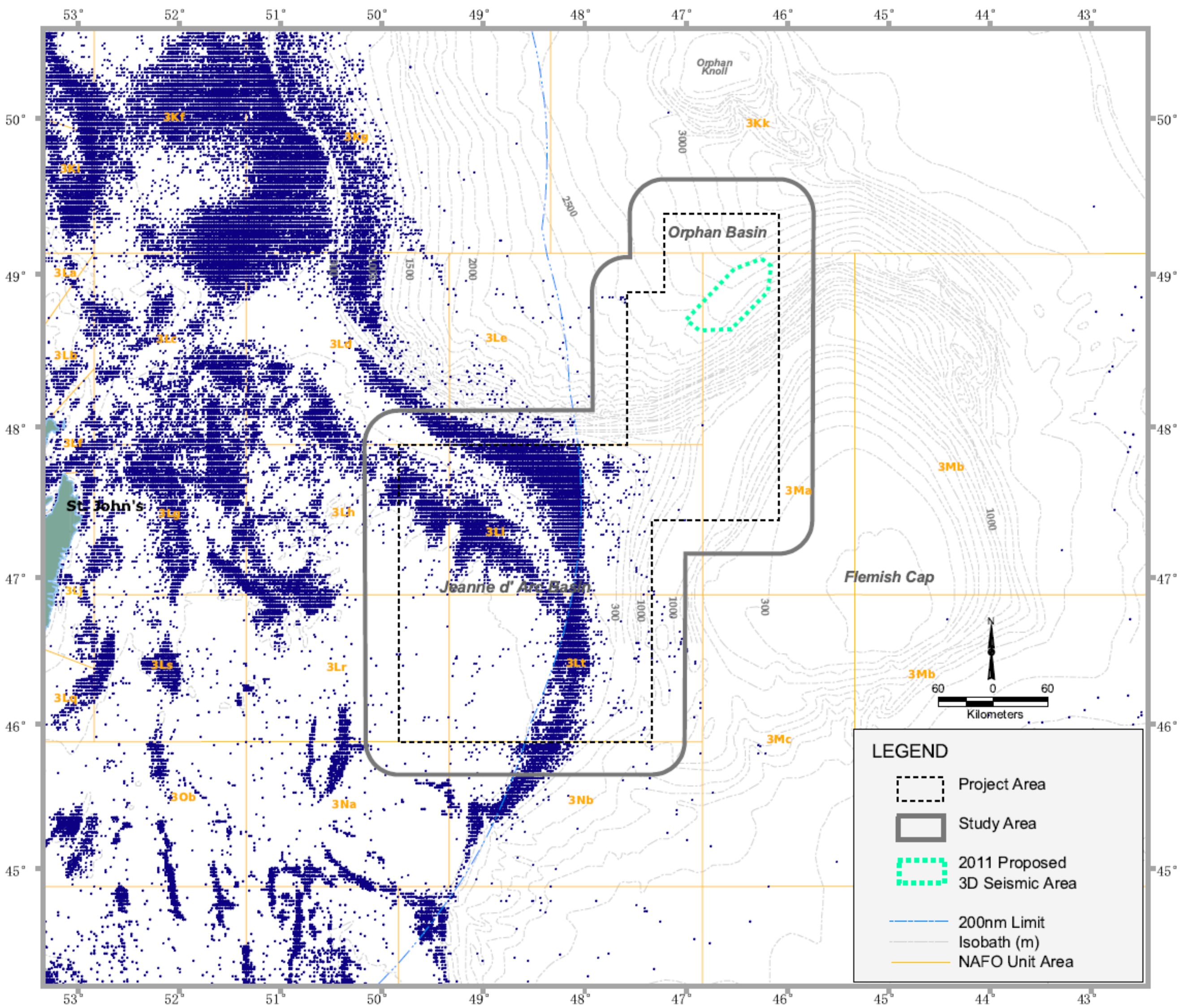


Figure 4.7. All species harvesting locations April to October, 2003 to 2009, aggregated.